THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. IX.—SEPTEMBER, 1902.

ORIGINAL ARTICLES.

I. — *Trogontherium* from a Pleistocene Deposit in the Thames Valley.

By E. T. Newton, F.R.S., F.G.S.

THE history of this gigantic rodent began to be written in 1809, when M. Gothelf Fischer described a skull from a sandy deposit on the borders of the Sea of Azof, to which he gave the name of *Trogontherium*. Since then, at varying intervals, to the present time, new chapters have been added to this history by both Continental and British workers, describing specimens of a more or less fragmentary character which have from time to time been discovered. The English specimens have been chiefly obtained from the 'Cromer Forest Bed,' that rich and remarkable series of beds occupying a position in time between the Crags and the Glacial deposits of East Anglia. The 'Forest Bed' specimens were first made known by Sir Charles Lyell in 1840, but were more fully described by Sir R. Owen in 1846 and referred to Fischer's *Trogontherium Cuvieri*. It will not be necessary at this time to refer specifically to each of the additions to our knowledge of this animal or to detail the varying opinions as to affinities and nomenclature, as these particulars will be found in the Memoirs of the Geological Survey of the United Kingdom.[1] Although most of the British specimens of *Trogontherium Cuvieri* have been found in the 'Cromer Forest Bed' a few examples have been met with in the Norwich and Weybourn Crags. The smaller species, which has been called *T. minus*,[2] was obtained from the nodule bed below the Red Crag of Felixstowe, and an incisor tooth from the Norwich Crag was referred to the same species. In 1892[3] the present writer

[1] "The Vertebrata of the Forest Bed Series," 1882, p. 65, and "The Vertebrata of the Pliocene Deposits of Britain," 1891, p. 51.

[2] Quart. Journ. Geol. Soc., vol. xlvi, p. 447.

[3] Trans. Zool. Soc., vol. xiii, pt. 4.

described a remarkably fine skull of *T. Cuvieri*, which had been obtained by Mr. A. Savin from the 'Forest Bed' of East Runton, and is now in the British Museum. The skull named by M. Laugel *Conodontes Boisvillettii*,[1] which is believed to be *Trogontherium Cuvieri*, was obtained from a bed at St. Prest, which is of about the same age as the 'Cromer Forest Bed.' The stratigraphical position of the deposit at the Sea of Azof, which yielded the original *Trogontherium Cuvieri*, still remains uncertain.

The above sketch will give an idea of our knowledge of *Trogontherium* ten years ago, and no addition seems to have been since made to the history of this interesting rodent. I am now, however, able to record its occurrence in a deposit of Pleistocene age in the lower part of the Thames Valley. In May of the year 1900 Mr. H. Stopes[2] gave an account before the Anthropological Institute of a bed of gravel (at 78 feet O.D.) on the west shoulder of the Ingress Valley, near Greenhithe, Kent, which is remarkable for containing great numbers of *Neritina fluviatilis*, together with many other species of mollusca and vertebrata. The extinct forms included among these fossils showed the deposit to be of Pleistocene age. Mr. Stopes has been careful to preserve all the mammalian remains he could obtain from this bed, but other workers have not been unmindful of the importance of this discovery, and, as may be gathered from Mr. Stopes' paper, they have secured some most interesting specimens. Mr. A. S. Kennard has made a large collection of the mollusca, and Mr. M. A. C. Hinton has obtained many vertebrate remains, chiefly the small forms included in Mr. Stopes' revised list. Another important series of bones has been secured by that assiduous worker Mr. W. J. Lewis Abbott, most of whose specimens are of species included in the published list, but there is one large rodent incisor (Fig. 1) which Mr. Abbott suspected from its size and shape might be *Trogontherium*. A rumour of this 'Great Beaver' from the 'Neritina' deposit seems to have been the cause of *Castor* sp. appearing in Mr. Stopes' list.

This incisor tooth was sent to me some twelve months ago, but I have delayed publishing an account of it, hoping that additional material would be forthcoming. The specimen (Fig. 1) is a lower incisor tooth, as shown by the large diameter of its curve in proportion to its thickness; it measures along the outer curve 132 mm., but is imperfect at both ends. The curve of the tooth, if completed, would form a circle with a diameter of about 150 mm. In cross section (Fig. 2) the tooth is pear-shaped; its width being 11 mm., and from front to back about 13 mm. The front is rounded and the hinder part has been angular, but this edge is nowhere quite perfect. The portion of the front of the tooth, which is covered by enamel, is shown in Fig. 2 by the thick dark part of this outline of the cross section. The inner edge of the enamel is slightly

[1] Bull. Soc. Géol. France, 1862, ser. II, vol. xix, p. 709.

[2] Journ. Anthr. Inst., vol. xxix, p. 302. This paper was reprinted in 1901 with a greatly extended list of fossils—67 species.

grooved from end to end, and the inner side of the tooth, which is not covered by enamel, is slightly concave. There is also a groove along the enamel near its outer edge, but the outer edge itself is rounded. The outer side of the tooth, uncovered by enamel, is slightly convex with an indistinct depression along the middle. The enamel of this tooth is everywhere rugose and granular, as shown somewhat enlarged in Fig. 3. The only large rodent from deposits of Post-Glacial age with which this tooth can be profitably compared is the Beaver. Compared with the lower incisor of a large specimen from the peat it is found to be absolutely longer, even in its present imperfect condition, and to have a markedly greater thickness. These differences of size would not alone suffice to indicate even a specific difference, but are of importance when taken in connection with differences in form and structure. The enamelled front of the Beaver's lower incisor is almost flat, so that the naturally worn cutting edge is straight and chisel-like. The tooth above described has a rounded front, and consequently in wearing would have a more pointed extremity. The enamel of the Beaver's incisor is smooth and shining, not rugose and granular like the present specimen.

Fig.3.

Fig.2.

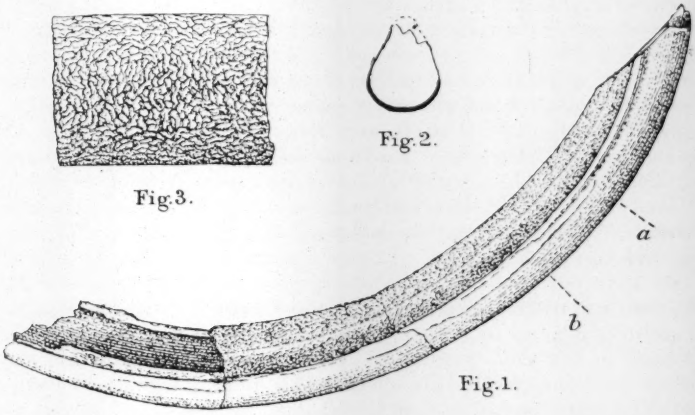


Fig.1.

Lower right incisor tooth of *Trogontherium Cuvieri* from the Pleistocene of the Thames Valley. Fig. 1, seen from the outer side, natural size; Fig. 2, cross section at *a*; Fig. 3, enamel between *a* and *b*, enlarged two diameters.

The lower incisor tooth of *Trogontherium Cuvieri* agrees with our Greenhithe specimen in all those particulars in which the latter differs from the Beaver; it has a similar rounded front, with rugose enamel, a similar cross section, and is remarkable for its large size. There can be no question as to the Greenhithe tooth being referable to the genus *Trogontherium*, the range of which in time must now be extended to the period of the High-Terrace gravels of the Thames, and it must have been contemporaneous with the fauna recorded by Mr. Stopes, which includes the mammals *Elephas*

antiquus, *E. primigenius*, *Rhinoceros leptorhinus*, *Bos primigenius*, and the molluscs *Pyramidula rotundata*, *Paludestrina marginalis*, *Unio littoralis*, *Corbicula fluminalis*, etc., together with many Palæolithic implements.[1] As this tooth presents no characters by which it can be differentiated from that of *Trogontherium Cuvieri*, it is provisionally placed in the same species.

II.—On the Genus *Peripristis*, St. John.

By C. R. Eastman, of Cambridge, Mass., U.S.A.

THE genus *Peripristis* was established in 1870 by Orestes H. St. John[2] for the reception of two species of Carboniferous fish-remains, one of which had been previously described by Newberry & Worthen under the name of *Ctenoptychius semicircularis*,[3] and was selected as type of the new genus. The other was known in collections and printed catalogues under Agassiz's manuscript title of *Pristodus falcatus*, but this name did not acquire validity until J. W. Davis adopted it in his monograph of 1883.[4] As there can be no question that the two species are congeneric, it follows that St. John's appellation of *Peripristis* has priority over Davis' term, and the type species becomes *P. semicircularis* (N. & W.) instead of *P. falcatus*, Davis.

The claims of *Peripristis* to recognition as a distinct genus were first impugned by J. S. Newberry, who, without having access to the foreign material associated by St. John with *P. semicircularis*, professed himself "unable to recognize more than specific differences"[5] between these teeth and those known as *Ctenoptychius serratus* and *C. dentatus*. Previous to this, however, Newberry had been inclined to separate the American form from other species of *Ctenoptychius*, but had refrained from so doing owing to insufficiency of material at his command for comparison. We find him writing in 1866 that "it is very apparent that the species which have been referred to *Ctenoptychius* require separation," and that the form named by him *C. semicircularis* differs so widely from *C. apicalis*, Ag., as to render it "doubtful if they should even be included in the same genus."[6] A few years later, after his suggestion had been carried into effect by St. John, and without having examined actual specimens of '*Pristodus*,' he saw fit to retract his former views, and his procedure in cancelling St. John's genus has been followed by subsequent writers. It is unfortunate that this error on Newberry's part should have been perpetuated, since even casual inspection shows that the types of *Peripristis* and '*Pristodus*' differ only in minor particulars, and that both are widely removed from *Ctenoptychius*.

[1] These implements have been figured and described by Mr. W. M. Newton in "Man" for June, 1901, art. 66.
[2] Proc. Amer. Phil. Soc., vol. xi (1870), p. 434.
[3] Pal. Illinois, vol. ii (1866), p. 72, pl. iv, fig. 18.
[4] Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 519, pl. lxi, figs. 17–22.
[5] Rept. Geol. Surv. Ohio, vol. ii (1875), p. 52.
[6] Pal. Illinois, vol. ii (1866), p. 73.

Notwithstanding the contrary opinion expressed by Jaekel,[1] we deem it entirely proper to recognize *Peripristis* as the type of an independent family, in view of the specialized character of its dentition. As already suggested by W. Davies[2] and A. S. Woodward,[3] it is probable, though not absolutely certain, that the dental series was reduced in this genus to a single tooth in the upper and lower jaw respectively. This is indicated not only by the form of the teeth, but by marks of contact which show that the opposing teeth interlocked when the mouth was closed, in a manner quite inconsistent with the idea that multiple series were present. The teeth are always bilaterally symmetrical, none having been found which correspond to the lateral series of Petalodonts. If we are to suppose with Jaekel that the symmetrically formed teeth were disposed in transverse series separated from one another by interspaces, then we must needs allow that they were adjusted with almost mathematical precision, and that there could have been not the least lateral play of the jaws in closing. Otherwise it would have been impossible for the functional rows of teeth in opposite jaws to have fitted as accurately into one another as is known to have been the case, the median acuminate apex of the lower teeth being received into a corresponding pit of the upper. So complicated a device as this theory calls for is unparalleled throughout the whole animal kingdom, and sets ordinary mechanical conditions at defiance. It is possible that our German friend has not taken considerations of this nature into account, or he would scarcely have hazarded the opinion "dass Pristodus mehr Querreihen als alle Petalodonten im Gebiss besass, und in deren schwacher Verfalzung die Entwickelung der Petalodonten einleitete. . . . . Wenn wir uns die Zähne von *Pristodus* in derselben Weise auf längere Kieferaste vertheilt denken, wie die von *Orodus* oder *Cladodus*, so hinderte nichts eine ungefähr symmetrische Ausbildung der einzelnen Zähne."[4]

It is the object of the following paragraphs to present a few new facts concerning the structure and distribution of teeth belonging to two species of this genus, namely, *P. semicircularis* and *P. concinnus*.

Family PERIPRISTIDÆ, nomen nov.

Genus Peripristis, St. John.

[Proc. Amer. Phil. Soc., vol. xi (1870), p. 434.]

Syn. *Hoplodus*, R. Etheridge, jun.: Geol. Mag. [2], vol. ii (1875), p. 244.
Diodontopsodus, J. W. Davis: Brit. Assoc. Rept., 1881, p. 646.
Pristodus, J. W. Davis (*ex* Agassiz MS.): Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 519.

Peripristis semicircularis (Newb. & W.).

1866. *Ctenoptychius semicircularis*, Newberry & Worthen: Pal. Illinois, vol. ii, p. 72, pl. iv, fig. 18.

[1] Zeitschr. deutsch. Geol. Ges., vol. li (1899), p. 290.
[2] Geol. Mag. [2], vol. ii (1875), p. 243.
[3] Cat. Foss. Fishes Brit. Museum, pt. i (1839), p. 62.
[4] Loc. cit., p. 292.

1870. *Peripristis semicircularis*, O. H. St. John: Proc. Amer. Phil. Soc., vol. xi, p. 434.
1872. *Peripristis semicircularis*, O. H. St. John: Hayden's Final Rept. U.S. Geol. Surv. Nebraska, p. 242, pl. iii, figs. 3, 4; pl. iv, fig. 20.
1875. *Ctenoptychius semicircularis*, J. S. Newberry: Rept. Geol. Surv. Ohio, vol. ii, p. 52, pl. lviii, fig. 14.

It is evident from marks of contact that the relations between the supposed upper and lower teeth of this species are identical with those known to obtain in *P. falcatus*, a specimen of the latter having been described by Davis which displays the dental plates of both jaws in natural association. The tooth which may be provisionally referred to the lower jaw in all these forms is the one which fitted inside that of the opposite jaw when the mouth was closed, the same condition being true of *Janassa*, and of sharks generally. The lower tooth of *P. semicircularis* (Fig. 1) differs from the upper in having the serrations of the cutting edge obsolete, or nearly so, and the inferior coronal margin deflected downward in the median line in front. Its root, also, is longer than that of the upper tooth. The trenchant margin of the latter is always strongly serrated in unworn specimens, there being usually four denticulations on one side of the median line and five on the other; the largest of these may be either central, or in some cases slightly eccentric in position. The coronal cavity of the upper tooth exhibits a deep pit in the

Fig. 1.

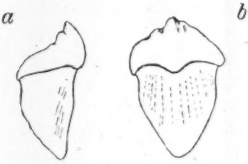


Fig. 2.

Fig. 1.—*Peripristis semicircularis* (N. & W.). Chester Group: Caldwell County, Kentucky. *a*, lateral aspect of lower tooth; *b*, anterior view: nat. size. (The indentations of the coronal margin are caused by contact with the serrated edge of the upper tooth, which closed outside the lower.)
Fig. 2.—*Peripristis bennici* (Ether.). Upper Carboniferous Limestone: Richmond, Yorkshire. Posterior aspect of upper tooth, nat. size.

median line at the junction of the horizontal and vertical portions of the posterior face, but there is no groove extending from it on either side as in *P. falcatus*. Occasionally this pit is developed into a perforation passing entirely through the horizontal portion of the crown. The close contact between upper and lower teeth is indicated

by fine vertical markings, and by the impress of the more prominent denticulations upon the outer coronal face of the latter, as seen in Fig. 1.

This species occurs in the Chester limestone of Kentucky, at the summit of the Mississippian series; in the Productive Coal-measures of Ohio and Indiana; and in the Missourian of Nebraska.

Peripristis benniei (R. Etheridge, jun.).

1875. *Petalorhynchus* (?) *benniei*, R. Etheridge, jun.: Geol. Mag. [2], vol. ii (1875), p. 243, pl. vii, figs. 3, 4.
1888. *Pristodus benniei*, R. H. Traquair: ibid. [3], vol. v, p. 101.
1889. *Pristodus benniei*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i, p. 64.

This species differs from *P. semicircularis* and *P. falcatus* in that the coronal margin of the upper tooth is not dentated, but acuminate and smooth, and with delicate punctations like the margin of the lower tooth, the latter being as in *P. falcatus*. It is stated by Smith Woodward that all the known teeth of this species, which occur typically in the Lower Carboniferous Limestone of Scotland and Derbyshire, are small in comparison with those of the Yorkshire species, and some doubt is expressed as to whether the non-dentated character of the margin of the upper tooth should not be considered as of generic value. The same author doubtfully assigns one upper tooth in the British Museum to this species, obtained from Richmond, Yorkshire, which appears to differ from the typical teeth only in size.

A second tooth from the same locality as the last, and apparently referable to this species, is preserved in the Enniskillen Collection belonging to the Museum of Comparative Zoology at Cambridge, and is shown of the natural size in Fig. 2. It is quite well preserved, exhibiting the character of the cutting margin with perfect clearness, and showing also several folds on the horizontal portion of the crown. It exceeds the specimen figured by Etheridge in size, and approaches that of *P. falcatus*. As the upper tooth of *P. concinnus* (Davis) has not yet been definitely recognized as such, there are no means of determining whether its coronal margin was serrated, as in *P. semicircularis* and *P. falcatus*, or smooth and acuminate, as in the species under discussion. In the latter event it would probably be difficult to distinguish between the upper teeth of *P. concinnus* and *P. benniei*, unless size alone were a criterion. The slight extent to which the coronal apex is produced in the present specimen, however, does not warrant its association with *P. concinnus* in the present state of our knowledge. Hence it may be affirmed that *P. benniei* accompanies the two other British species of *Peripristis* at the Richmond locality.

III.—The Wood's Point Dyke, Victoria, Australia.

By F. P. Mennell, F.G.S., Curator of the Rhodesian Museum, Bulawayo.

THE Wood's Point Dyke is intrusive in a belt of Silurian (Upper Silurian) strata which strike in a direction somewhat west of north and extend beyond Walhalla on the south. Wood's Point is about 75 miles from Melbourne in an easterly direction, and is not situated on the coast as might be inferred from its name. The nearest sea-water is, indeed, some 60 miles distant. The dyke has a north-west by south-east bearing, and it may be taken as typical in many respects of the intrusions which are frequently associated with the Silurian rocks of the Victorian goldfields, though it presents several peculiar features of considerable interest. It penetrates strata of different lithological characters, and, as might be expected, varies considerably both in texture and in the relative abundance of its mineral constituents along its course. That absorption of the surrounding rocks has taken place to a considerable extent may be taken for granted from certain of the modifications which are exhibited. In several particulars, however, specimens from different points along the outcrop agree, not only with one another, but with many of the other Victorian Palæozoic but post-Silurian intrusions. We have, indeed, an illustration of what seems to be a general rule, that precisely similar minerals tend to develop in all parts of the same magma, even when the various portions differ considerably in chemical composition, unless the variations reach an extreme point. In other words, the relative acidity or basicity of different portions are expressed by differences in the proportions of the same minerals rather than by the development of other minerals of more acid or more basic character.

Hand-specimens representing the average appearance of the Wood's Point rock are dark-coloured and distinctly granitic in texture. The specific gravity ranges as high as 2·9, and the closeness of grain enables it to retain a good polish which might make it valuable in the future for ornamental purposes. Under the microscope it is seen to depart widely from a truly plutonic structure. Hornblende is the dominant constituent, though both augite and enstatite are also present. It forms larger crystals than any of the other minerals, but it is certainly not 'porphyritic' in the strict sense of the term. The word 'porphyritic,' if it has any real scientific application at all, must be held to characterize a mineral as of prior consolidation to, if not as actually belonging to an earlier generation than, the remaining constituents. In the present instance, despite its relative development, the hornblende rarely shows the crystal outline which would indicate early consolidation. In fact, it is sometimes moulded on felspar, and there are even indications of an ophitic structure in the occasional penetration of a crystal by idiomorphic crystals of the latter mineral. The colour of the hornblende is brown, which, as pointed out by Teall,[1] is seldom or never the case with the varieties derived from augite

[1] "British Petrography," p. 166.

That it is original in the present instance can scarcely be doubted, despite the occurrence of the pyroxenes. The prism angles, where seen, are those proper to the species, and there are no traces of the wedge-shaped outgrowths or fibrous structure so characteristic of the uralitic varieties. The pleochroism is striking, giving deep yellow brown for c to nearly colourless for a, while the interference tints are frequently to some extent masked by the strong absorption. The extinction angle in longitudinal sections reaches a maximum of 18°, while a twin in which the sharp boundary of the individuals showed it was cut parallel to the clinopinacoid, gave 13° on each side of the composition plane.

The pyroxenes are distinguished from the hornblende by their cleavage and extinction angles and their want of colour. The augite shows distinctly stronger refraction and double refraction than the hornblende, while the enstatite gives low interference tints and shows the straight extinction in several longitudinal sections. The augite is sometimes surrounded by hornblende; it may, however, be regarded as an inclusion in the latter rather than as intergrown with it.

Fig. 1.—Hornblende Porphyrite. Crossed nicols, × 50 diam.

The felspar does not all belong to the same period of consolidation; indeed, it seems to have been developed in at least three distinct generations or regenerations. The largest crystals, those which are idiomorphic towards the hornblende, belong to the first period, smaller crystals and microlites represent the second generation, while other small crystals, much the freshest constituents of the rock, must be regarded as in all probability of secondary origin. The first class have undergone decomposition to such an extent that they are nearly opaque. They appear, however, to extinguish almost straight, and unless this is an effect of decomposition they would seem referable to oligoclase. The second series are somewhat fresher and exhibit both the Carlsbad and Albite types of twinning, though the lamellæ in the latter case are never numerous. A few

examples show Pericline lamellation as well. The maximum extinction angle in cases where the lamellæ give approximately symmetrical extinctions is about 21°, so that the species appears to be andesine. The third variety includes examples which are clear, and are often indistinguishable from quartz, except by convergent light, in cases where there is no twin lamellation. In a few instances they show a decomposed core, and the peculiar form of zoning is also seen which Professor Judd[1] has ascribed to growth after the consolidation of the rock. Well-marked lamellar twinning is sometimes shown, and the species approaches albite, though the outer layers are evidently more acid than the interior, as shown by their increasing angle of extinction. There is yet another form of felspar to be described, that which occurs in considerable abundance intergrown with quartz. In places it gives to a slice the appearance of a typical granophyre. The quartz and felspar occasionally radiate in pseudo-spherulitic fashion from a centre, which is sometimes marked by an idiomorphic crystal of decomposed felspar. The felspar of these micrographic intergrowths is usually referred to orthoclase, microcline, or other acid type; in the present instance decomposition prevents any attempt to determine the variety. The quartz frequently presents beautifully sharp triangular sections, contrasting markedly with the cloudy felspar. Larger isolated granules also occur, but for these a secondary origin is generally to be suspected.

Of what are usually termed accessories ilmenite is by far the most abundant, being even noticeable on a polished surface of the rock. It is, no doubt, the source of the 'titaniferous ironsand' so common in the auriferous wash of the neighbourhood. Incipient forms of growth are the rule even in the largest crystals, which are usually built up of plates or rods intersecting at angles of 60° and 120°, the best developed ones giving a somewhat elongated hexagonal section. In many cases the mineral is quite fresh; frequently, however, leucoxene has been formed through interaction with the decomposing felspars. Occasionally the change has been complete, and nothing remains but a semi-opaque patch of leucoxene, but in most instances the internal structure of the original mineral is revealed in a most striking manner, a lattice-work skeleton of ilmenite being often left which shows up beautifully by reflected light. Apatite is another accessory and is also common. Some of the prisms are short and stout, and show good terminations; usually, however, the crystals are acicular and very long, several so thin as to be almost opaque, attaining a length of nearly 2 mm. Pyrites and calcite occur as decomposition or infiltration products, but they call for no special notice. There is also a micro- or crypto-crystalline groundmass present in most slices, and what seems to be some residual glass. It is almost colourless, and looks perfectly homogeneous by ordinary light. Between crossed nicols, however, it shows feeble double refraction, with here and there an approach to spherulitic structure. It has been suggested to me that this might possibly

[1] Q.J.G.S., May, 1889, p. 179.

be a chloritic or serpentinous decomposition product, but from its relation to the other minerals this seems very unlikely, and it may be looked upon with some certainty as devitrifying glassy material.

The above description applies to the leading (and most basic) type, which may be classed as a hornblende porphyrite, the term porphyrite being applied in the sense of a hypabyssal equivalent of the diorites. A few varieties, apparently coarser-grained in the hand-specimen, show, curiously enough, considerably more crypto-crystalline groundmass, while in the finer-grained varieties the hornblende is much more frequently idiomorphic and takes on forms similar to the basaltic variety. One fine-grained marginal modification is very acid in character, being of a grey colour in hand-specimens and showing minute cavities. The silica, kindly determined for me by Mr. L. Ludlow, reaches the high figure of 77·4 per cent. The chief feature of interest is the occurrence of cordierite, distinguished by its peculiar twinning and its biaxial interference figure in convergent polarized light. Most of the granules show some approach to crystal outline and are twinned, the interference tints of the individuals being different in cases where the extinctions are simultaneous. One crystal, though not quite perfect, nevertheless well illustrates the multiple twinning of the mineral (see Fig. 2). It differs from the form figured by Rosenbusch [1] in the fact that the twin planes bisect the sides, not the angles, and the boundaries of the individuals are somewhat irregular, while an extra one is wedged in between two of the others.

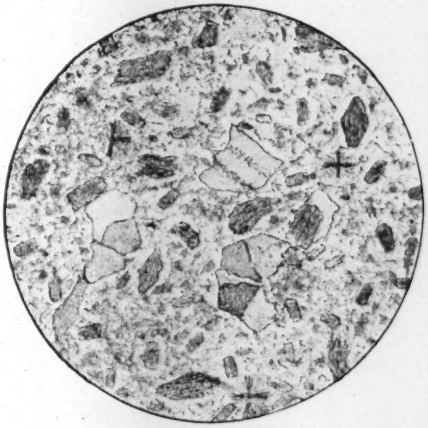


Fig. 2.—Cordierite Felsite. Crossed nicols, × 50 diam.

Osann has accounted for the presence of primary cordierite in a somewhat similar rock as due to the complete absorption of fragments of cordierite gneiss, resulting in the local formation of a magma containing an abnormal percentage of alumina, from which cordierite crystallized out in due course. In this case we have no

[1] "Mikroskopische Physiographie," pl. xviii, fig. 1.

cordierite gneiss to account for the occurrence, but we have plenty of aluminous material in the adjacent shales, and, as Teall has justly pointed out,[1] there is no reason why the mineral should actually be present in the absorbed rock. None of the other minerals which are genetically connected with cordierite and almost constantly accompany it are present in the numerous slices I have examined, unless some small brilliantly polarizing crystals are to be referred to sillimanite. No separate determination of the alumina has been made, but the combined alumina and ferric oxide come to 19·8 per cent., an extremely high figure in so acid a rock, leaving less than 3 per cent. unaccounted for, after taking the silica into consideration. The iron certainly cannot be present in large quantities, ilmenite, pyrites, etc., being entirely absent from this part of the rock, while the ferro-magnesian minerals (chloritized hornblende and granular augite) are very sparingly distributed.

The intrusion of such dykes as the one described is evidently related to the formation of the associated auriferous veins. In the case of the Victorian Silurian deposits the reefs are almost invariably connected with intrusive rocks, while those in the Ordovician strata usually occur at or near the contact with great plutonic masses. It seems highly probable, as Mr. Howitt has suggested,[2] that on following down a dyke formation it would be found to end as a contact deposit on reaching its plutonic source. At Wood's Point the reefs are nearly horizontal, traversing the dyke and the shales in the immediate vicinity, the junction usually marking the occurrence of rich ore. Mineralization evidently went on coincidently with or very soon after the intrusion of the dykes during Devonian times; indeed, in New South Wales and in Queensland, where the conditions are very similar, detrital gold has been worked in mechanical sediments of Lower Carboniferous and Permo-Carboniferous age.

Where the gold came from is a question not easy to answer. Some of the Victorian dykes have been found on analysis to contain gold, sometimes as much as $\frac{1}{2}$ oz. to the ton, but it may always be argued that the enrichment of the dyke was due to the same causes as that of the lodes themselves. It seems to be generally believed that the mineralization took place from below; to my mind, however, the evidence seems to point to the leaching out and redeposition of the minute quantities of gold present in the shales by the action of heated acid waters connected with the intrusion. A fact which has, however, frequently struck me is the almost invariable association of gold in this class of deposit with rocks containing *original* hornblende, and it has been noted in New South Wales that in every case where auriferous reefs are associated with granite the latter is hornblendic.[3] Whether there is any significance in this association remains to be seen, but it certainly seems worthy of further investigation.

[1] Pres. Address to Geol. Assoc. 1899.

[2] "The Downward Extension of Quartz Reefs": Ann. Rep. Chamber of Mines of Victoria, 1901, p. 36.

[3] G. F. Pittman: "Mineral Resources of N.S.W.," p. 62.

IV.—A Fragment of Physical Geography: The Past and Present of a bit of Dartmoor.

By Harford J. Lowe, F.G.S.

INSTANCES of alteration of the courses of streams are common, but these changes are met with for the most part in the alluvial plains and flood areas at low elevations where the streams are approaching their termination in sea or lake. The instance here noticed is of a rarer kind, where a small Devonshire stream, the Bovey River, has accomplished, with the help of contributory forces, earth sculpture apparently enormously out of proportion to its present insignificant dimensions, and managed to shorten its journey to join the Teign by altering the direction of the middle part of its course at a point where its elevation is considerable.

The village of Lustleigh is well known to most visitors to South Devon as a resort frequented for its beautiful situation and surroundings. It lies on the eastern edge of Dartmoor where three narrow and precipitous valleys join the broader one which runs from Bovey to Moretonhampstead. Lustleigh is particularly distinguished to visitors by what is called the Cleave. The name, instead of being used for the valley or cleft, is in popular parlance applied to a ridge of granite of wedge shape about two miles and a half in length, upon the slopes of the narrow end of which most of the village of Lustleigh lies. This end of the 'Cleave' is crowned by a noble disorder of granite masses which is named from a rocking-stone, much used for the purpose indicated, 'The Nut Crackers.' From here in a north-west direction the crest of the ridge gently rises to another Tor or assemblage of bare granite masses called Raven Rocks, beyond which the ridge widens and rises to 1,068 feet, and near some ancient earthworks is given the very appropriate name of Hunters' Tor, in that it is a most excellent view point in all directions. This ridge, which for convenience sake I will call as a whole the Cleave, is in some respects unique amidst Dartmoor scenery, in that it more than any other portion of Dartmoor is cut away from the main elevated moorland by valleys and depressions on all sides. In consequence, from several points of view it commands particular notice by standing out in apparent independence, while all other prominences are seen to be connected, by only slight depressions in the skyline, to the central area of Dartmoor.

As shown in the accompanying sketch-map, the north-east and south-west boundaries of the 'Cleave' are formed by narrow deep valleys, which meet at the wedge point where the confluent streams have an elevation of less than 200 feet above the sea-level. The Bovey River flows along the gorge on the south-west, while on the north-east a tiny stream has cut a valley from the northern part of the Cleave parallel to the Wray, which half a mile to the east over an intervening elevation of only 700 feet occupies the Moreton-hampstead valley.

The northern boundary of the 'Cleave' is marked by a depression along which a motley assortment of ill-grown trees and undergrowth has obtained possession. This narrow band of wood-covered land is found on closer examination to be very uneven ground, made up for the most part of ridges and holes evidently of artificial arrangement. The place, with its repellent pools of stagnant water, overhung by sprawling trees whose roots and lower branches bear trails of green slime left on them by the subsiding water, strikes one as a weird spot, fit home for the Dartmoor pixies. Locally the place

FIG. 1.—Sketch-map of a portion of the Eastern border of Dartmoor. The numbers indicate the heights in feet above O.D.

is known as Peck Pits, and has been referred to by a native as a 'ghastly place.' The disturbance of the material, probably by the old tin streamers, reveals a considerable depth, some 20 feet or more, of gravel, varying in consistence from coarse sand to a rubble of from 3 to 5 inches in diameter. A crude arrangement of the material as regards size can be made out, the coarser lying at the foot of the Tor. All the stones of which this deposit is formed are much water-worn, many being quite rounded, with few that are better described as subangular. The deposit rests upon and is well within the granite area, and contains nothing outside the products of the granite mass. Most of the material is derived

from the hardest varieties of the granite, viz., the schorl rock, elvans, and quartz veins; but the former constitutes much the greater proportion of the coarser material, and there is very little of the more easily disintegrated porphyritic granite to be met with.

Receding from the foot of the Tor the drift material becomes finer, and finally as sand mixed with humus forms cultivable land. A cutting made by a roadway through a portion on the opposite side of the strip from the Tor shows sand of varying degrees of coarseness, roughly stratified, with the finer material increasing upwards.

From the description it will be seen that the materials are all water-worn and water-borne, and are sorted out after the manner of river drift where a stream, turned from a direct course, by wearing away the opposing mass loses much of its carrying power while increasing the area of drift deposit at the bend.[1]

There is, then, little doubt that this drift now lying far above the present bed of the Bovey stream is the work of that river, a deposit made in its earlier and probably more vigorous age, when its course was along the north side of Hunters' Tor and down the broader Moretonhampstead valley, now occupied by the puny Wray stream. But while it was expending its force in shearing a drift area on the north side of the Tor, a small stream on the south-west of the Cleave was cutting its way back in a north-westerly direction and thus gradually approaching the bend of the larger stream, until the gradually narrowing ridge dividing the principal from the subordinate valley became worn down to the level of the higher and main stream, when it would leave its old circuitous course and descend the more direct and precipitous one towards its destination. The old course and the approaching valleys are indicated on the following map.

Half a mile south of the river-deserted patch of gravel and near to the newer and present course of the Bovey stream stands the farmstead of Foxworthy, remembered probably by some who may read this note as the moorland retreat of a well-known geologist and friend of geologists—Mr. A. R. Hunt, M.A., F.G.S., etc., who directed the Geologists' Association for the day and entertained them at this delightful spot (Easter, 1900).[2] To him I am much indebted for geological help, and indeed he introduced the problem of the drift, a solution of which is here offered. Close to Foxworthy estate is a peculiarity in the channel of the river that may be accounted for by the turning of the greater stream into the course of a small tributary. Horsham Steps (see Map 1) is an extraordinary aggregation of granite boulders choking the river channel for a considerable number of yards. These boulders are, generally speaking, very massive, so that the interstices are sufficiently large to allow all the water to pass through them except at times of freshets of more than average volume. The boulders are so piled together that they form a natural fording-place at most states of the stream, which at

[1] References to the valley deposits are made in papers by G. W. Ormerod, Quart. Journ. Geol. Soc., vol. xxiii, p. 425, and Prestwich, GEOL. MAG. for 1898, p. 414.

[2] Proc. Geol. Assoc., vol. xvi, p. 430.

ordinary flow is almost hidden several feet below the highest 'steps.' Now it is well known that granite weathers irregularly. Frequently harder cores occur which resist decay and stand above the disintegrated surface. These, by processes due to temperature, denudation, and gravity, gradually make their way to the bottom of the valley. They are to be met with in most granite areas, scattered about in what might paradoxically be called an irregularity that has a kind of uniformity about it. Now Horsham Steps has no parallel that I am aware of, and it seems to me probable that the boulders found their way into the bed of the minor stream in

Fig. 2.—Former drainage of same area as represented in Fig. 1.

the usual scattered fashion, but that the somewhat sudden increase of the stream by the addition of the waters of another river with much greater volume increased its force and carrying power sufficiently to drive together the boulders strewn along a rapid portion of its course, in such a manner that they formed a support to each other and thus became an immovable barrier and unusual feature.

As there are data upon which to base calculations, it will be of interest to form some idea of the time which has elapsed since the river changed its course. Lord Avebury, in his "Scenery of England," cites Croll as estimating the mean rate of erosion by rivers as one

foot in 3,400 years. Mr. Charles Davison (Geol. Mag., December, 1889, p. 411) gives reasons for thinking a foot in 2,400 years more probable. Now if we take the average of these estimates, and make allowance for the probably more rapid lowering of the bed of a river in its earlier history, as well as steeper parts, we might take 2,500 years per foot as the index of erosion for the Bovey stream in its upper course. As shown on the map the old river gravel stands at an elevation of 750 feet, while the present height of the river at that point where it changed its course is 630 feet, so that it might be taken that it has followed its present course west of the Cleave for some 300,000 years. Yet this is but a short stage in its history, for from data used by Professor Sollas in his address to Section C at the Bradford Meeting of the British Association, it must be some $3\frac{1}{2}$ millions of years ago since this same stream was helping to fill up the Eocene lake and depositing the material that is known as 'the Lignite formation of Bovey Tracey.'

V.—Notes on Dr. G. F. Matthew's Cambrian Ostracoda from North-Eastern America.

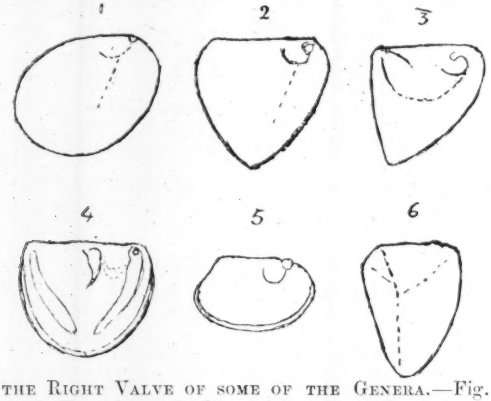
By Professor T. Rupert Jones, F.R.S., F.G.S.

FOR many years Dr. G. F. Matthew, of St. John, New Brunswick, has given much attention to the geology and fossils of the districts lying on or near the north-eastern seaboard of North America, and has closely studied their minute fossils resembling (if not identical with) varieties of small bivalved Entomostraca; and he has published his results from time to time in the scientific periodicals of Canada and the United States.

One of the first of his descriptive memoirs on these peculiar microzoa is in the Transactions of the Royal Society of Canada, vol. iii, 1886, and treats of some of these remarkable little organisms from the St. John's Group of Cambrian strata, at pp. 61–66, figs. 16–21, under the names of *Lepiditta*, *Lepidilla*, *Hipponicharion*, and *Beyrichona*, some being regarded as Ostracoda and others doubtfully as Phyllopoda. They were referred to in the Reports British Association, 1889, p. 174, and too hastily supposed to be possibly opercula of Pteropods; they must evidently be accepted as members of the Ostracodous group.

The terminology used by Dr. Matthew for these little organisms can be readily collated and fitted in with the descriptive terms used by other palæontologists for similar or allied forms. The modifications of the ovate-oblong valves and of their relative convexity are not strange, except that the ventral border in some of these forms is very much expanded obliquely downwards and backwards, becoming more or less triangular. The 'ocular tubercle' is high up in the antero-dorsal corner or angle of the valve; and is often accompanied or surrounded by a circular indication of what Dr. Matthew regards as the mark of the anterior adductor muscle. The central muscle-spot, common in the Leperditian family, is not recognized. Most of the described specimens the author

refers to the new family Bradoriidæ; and they appear to be allied to *Aparchites* and *Leperditia*. *Hipponicharion*, by its superficial ridges, seems to be the only representative of the Beyrichiidæ.



Outlines of the Right Valve of some of the Genera.—Fig. 1, *Indiana*; 2, *Bradorona*; 3, *Beyrichona*; 4, *Hipponicharion*; 5, *Bradoria*; 6, *Escasona*.

In pl. i of the memoir No. 10, figs. 1–6 (here copied) are: "Diagrammatic figures of genera to show important characters referred to in the text—*o*, ocular tubercle; *m*, scar of adductor muscle; *c*, cardinal or hinge-line; *a*, anterior cardinal curve; *b*, posterior cardinal curve; *e*, anterior marginal curve; *d*, posterior marginal curve; *v*, ventral margin."

The small letters *o* to *v* are omitted for the sake of clearness in these copies, but the features referred to are sufficiently distinct.

The following list indicates the succession and subjects of those of the above-mentioned memoirs that contain descriptions and often illustrations of these very ancient Entomostracan remains:—

No. of Mem.	Date.	Particular Faunæ and Formations.	
1	1886	Lower Cambrian: St. John Group	Trans. Roy. Acad. Canada, vol. iii.
2	1890	Lower Cambrian	Trans. Roy. Acad. Canada, vol. vii.
3	1894	Lower Cambrian	Trans. Roy. Soc. Canada, vol. xi.
4	1895	*Protolenus*-zone	Trans. New York Acad. Sci., vol. xiv.
5	1896	*Paradoxides*-zone	Trans. New York Acad. Sci., vol. xv.
6	1898	Cambrian: St. John	Trans. Roy. Soc. Canada, ser. II, vol. iv, sect. 4.
7	1899	Etcheminian group of Cape Breton	Bull. Nat. Hist. Soc. New Brunswick, VIII, vol. iv.
8	1899	Etcheminian group of Newfoundland	Trans. Roy. Soc. Canada, ser. II, vol. v, sect. 4.
9	1899	Etcheminian group of Newfoundland	Bull. Nat. Hist. Soc. St. John, New Brunswick, XVIII, vol. iv.
10	1902	Etcheminian of Cape Breton ...	Canadian Record Sci., vol. viii.

The geological formations or terranes of the north-eastern part of America concerned in Dr. Matthew's researches are noted in the memoir No. 4, p. 102, as—

Upper Cambrian ...	*Ceratopyge* fauna	Upper Tremadoc.
	Peltura fauna	Lower Tremadoc.
	Olenus fauna	Lingula Flags.
Lower Cambrian ...	*Paradoxides* fauna	Menevian and Solva.
	Olenellus fauna [1]	Caerfai Group.

[1] At p. 105 referred to the Etcheminian stage of Pre-Cambrian age.

The St. John Group in the Cambrian terrane of New Brunswick is given in memoir No. 4, pp. 105 and 109, as follows :—

Cambrian	Division 3.	Bretonian ...	*Tetragraptus* fauna.
	,, 2.	Johannian ...	=place of the *Olenus* fauna.
Pre-Cambrian...	,, 1.	Acadian ...	*Paradoxides* and *Protolenus* fauna.

The Ostracoda peculiar to the three divisions or zones of the Etcheminian terrane underlying the St. John Group in Cape Breton, and to the still lower Coldbrook terrane, are tabulated at pp. 438 and 439 in memoir No. 10.

List of Genera and Species of Ostracoda from Lower Palæozoic Strata, described by Dr. G. F. Matthew, 1886-1902.

Date.		Memoirs.	Date.		Memoirs.
1886.	*Hipponicharion eos* . .	1, 2, 3	1895.	*Schmidtella Cambrica* .	4
1894.	,, *cavatum* . .	2, 3	1899.	,, ? *perretus* and 1 mutation .	7, 10
1894.	,, *minus* . .	2, 3	1899.	,, *avita* . . .	7, 10
1886.	*Beyrichona papilio* . .	1, 4	1898.	*Beyrichia* ? *primæva* .	6
1886.	,, *tinea* . . .	1, 5	1899.	*Bradoria*[5] *scrutatrix*[6] .	7, 10
1895.	,, *planata* .. .	4	1899.	,, *vigilans* and 3 mutations	7, 10
1895.	,, *triangula* .	4	1899.	,, *rugulosa* and 1 mutation .	7, 10
1895.	,, *ovata*[1] . .	4	1899.	,, ? *ornata* . .	7, 10
1895.	,, *rotundata* .	4	1899.	*Aptychopsis terra-novica* and 1 mutation.	8, 9
1886.	*Primitia acadica* . .	1, 4	1902.	*Bradorona*[7] *perspectrix* and 3 mutations	10
1894.	,, *aurora*[2] . .	3, 4	1902.	,, *spectatrix* and 3 mutations	10
1895.	,, *oculata*[2] . .	4	1902.	,, *observatrix* and 1 variety and 2 mutations	10
1895.	,, ? *fusiformis* .	4	1902.	*Escasona*[8] *rutellum* . .	10
1898.	,, *pyriformis* .	6	1902.	,, ? *vetus* . .	10
1886.	*Lepidilla*[3] *alata* . . .	1, 5	1902.	,, ? *ingens* . .	10
1886.	,, *anomala* . .	1	1902.	*Indiana ovalis* and 1 mutation .	10
1886.	,, *curta* . . .	1, 5	1902.	,, *lippa* . . .	10
1894.	,, *auriculata* .	3, 5			
1894.	,, *sigillata* . .	3, 4			
1890.	*Leperditia* ? *ventricosa* .	2			
1890.	,, ? *Steadi* . .	2			
1895.	,, ? *minor* . .	4			
1895.	,, ? *primæva* .	4			
1902.	,, *rugosa* . .	10			
1895.	*Aparchites*[4] *secundus* .	4			
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In the foregoing list there are enumerated 13 genera, comprising 43 species, with 1 variety and 15 mutations (changes or stages).

[1] *Beyrichona ovata* of the *Protolenus*-zone is referred to the genus *Escasona* at p. 458 of memoir No. 10.

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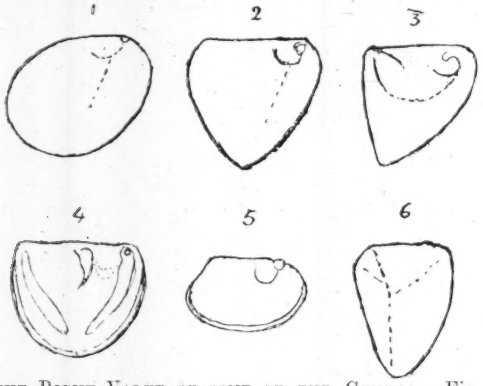

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1894.	,, *sigillata* . .	3, 4			
1890.	*Leperditia* ? *ventricosa* .	2			
1890.	,, ? *Steadi* . .	2			
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VI.—Note on the Upper Chalk of Lincolnshire.

By William Hill, F.G.S.

In the Geology of East Lincolnshire, a memoir of the Geological Survey published in 1889, the whole of the flint-bearing Chalk of that county above the Melbourn Rock was referred to as Middle Chalk, and no horizon was found which could be regarded as the equivalent of the zone of *Holaster planus*, or the Chalk Rock of the Midland counties.

As our knowledge of the fossils of the Upper Chalk increased, the occurrence of *Infulaster excentricus*, *Echinoconus globulus*, and *Rhynchonella limbata*, which had been collected by Mr. Rhodes from a quarry at Acthorpe, near Louth, suggested to Mr. Jukes-Browne that there might after all be some part of the Upper Chalk exposed in north-east Lincolnshire; and for the purpose of obtaining evidence on this point I made two visits to this locality in 1897 and 1898, and was fortunately enabled to establish the fact of its existence in this county. The zone of *Holaster planus* was well marked in a quarry near Boswell Farm, half a mile north-west of North Elkington, about three miles north-west of Louth. The section here was as follows:—

	ft.	in.
Clayey gravel and chalk rubble	6	0
White chalk with three layers of large flat flints and some scattered flint nodules. *Echinocorys scutatus*, *Micraster Leskei* ...	5	6
Firm white chalk, *Micraster Leskei*	3	0
A thick continuous floor of flint	0	5
White chalk, rather harder, with *Holaster planus*, *Micraster Leskei*, and *Echinocorys scutatus*	2	9
A thick layer of intermingled chalk and flint	0	8
Firm white chalk with a layer of large flat flints (partly obscured)	6	0
Harder chalk with two layers of intermingled chalk and flint ...	7	0
	31	4

The typical fossils of the zone occurred in the upper part of the section only; the specimens of *Micraster Leskei* were large ones.

Quarries to the eastward between Elkington and Fotherby, and again near North Ormsby, expose another set of beds, which must be very nearly on the same horizon as those at Boswell, and are different from any seen to the south of Louth. These beds have been described in the memoir of the Geological Survey, and are characterized by the existence of continuous floors of grey flint, each about 6 inches thick, these flint layers often containing inclusions of hard yellowish chalk. Fossils are not common in these beds; Mr. Jukes-Browne informs me that Mr. A. Burnet, of Leeds, has recently found some in the quarry about three-quarters of a mile west-south-west of Fotherby, though unfortunately they are not sufficient to prove the exact age of the Chalk containing them. Mr. Jukes-Browne has identified them as follows: *Septifer lineatus* (in flint), *Inoceramus Brongniarti*? *Plicatula sigillina*, *Rhynchonella Cuvieri*, *Serpula* sp., and a spine of *Cyphosoma*. The occurrence of *Septifer lineatus* is

noteworthy, as it is not uncommon in the zone of *Holaster planus*, but it is curious that Echinoderms should be so rare in this set of beds.

There is no appreciable dip in either of the above-mentioned quarries, and it is therefore impossible to say for certain whether the chalk near Fotherby is stratigraphically higher or lower than that at Boswell, but the balance of available evidence is in favour of their being a little lower, for the Fotherby quarry is at a rather lower level than the other, and the absence of *Echinocorys* suggests a lower horizon.

Similar chalk with intercalated layers of flint extends northwards along the eastern border of the Chalk Wolds, and exposures of them are mentioned in the Survey memoirs on the geology of Sheets 83 and 86, but no fossils indicative of Upper Chalk were obtained from any of them. In 1899, however, I found Chalk with *Holaster planus* in a quarry half a mile south-east of Kermington, near Brocklesby, where the following succession was visible :—

	ft.	in.
Soil and rubble	4	0
Hard white chalk, weathering into thin irregular platy pieces ...	1	9
Continuous layer of solid grey flint	0	5
Hard white chalk as above, with layer of flat lenticular flints ...	3	6
Continuous layer of solid grey flint	0	6
White chalk, rather soft and shaly, at the top *Holaster planus* ...	1	0
Hard white chalk, breaking into thin flattish pieces	3	6
Grey flint, nearly continuous, but separated in places into detached tabular flints	0	6
Hard white chalk with only a few scattered nodular flints ...	9	0

From the lithological characters seen here I believe this quarry is just in or just below the zone of *Holaster planus*. In the large Chalk quarries at Barrow I found a good specimen of *Echinocorys scutatus*, besides fragments which I should refer to this species. The lithological features of the Chalk at this horizon are well marked ; the Chalk itself is firm, almost hard, and weathers into thin platy pieces, becoming softer at the higher horizons. The flint, besides occurring in the ordinary nodular form, occurs also in lenticular masses five or six inches thick, which can only be described as 'tabular,' though they do not form the even continuous floor seen in the tabular flint of the South Coast cliffs. They present rather the appearance of a series of large mammillated flints all on the same plane, merging in places to one unbroken layer of considerable extent.

From the foregoing evidence the fact that Upper Chalk occurs in Lincolnshire seems well established. I could find, however, no evidence to indicate an exact horizon which could be taken for its base, nor could I find a quarry or series of quarries to give me the passage of Chalk with flint nodules in the zone of *Terebratulina* to that of Chalk with the tabular flint layers.

The lithological features which are associated with *M. Leskei*, *H. planus*, and *Echinocorys scutatus*, viz., firm chalk with layers of massive tabular flint, passing upward to softer chalk with nodular flint, continues through Yorkshire. For instance, *H. planus* associated with *Echinocorys scutatus* occurred in chalk with massive tabular flint

in the railway cutting just west of Enthorpe Station, near Market Weighton. The overlying chalk was softer with flint nodules, and here and there a tabular layer.

A small quarry at the turning of the lane to Goodmanham Lodge Farm showed three layers of tabular flint. *Holaster planus* was common in the Chalk. The position of this quarry is just beyond a cutting (now grassed over) in the railway west of Kipling Cotes Station, where Mr. Allen, collector for the Geological Survey, found *Micrasters* now referred to as *Micraster præcursor*. The horizon of the quarry is a little lower than the cutting.

The Chalk in Yorkshire containing layers of flint has been noticed by Professor Blake, who, unable to agree with the divisions of Barrois, formulated a classification based on the characters of the flints.[1] He gives a thickness of 50 feet to "Chalk with tabular flint," and calls it the barren zone. This "Chalk with tabular flint" is undoubtedly the continuation of that of Lincolnshire, and we may take it as being roughly the equivalent of the nodular Chalk of the south-east of England and of the Chalk Rock of the Midland counties.

VII.—On some Examples of Marine and Subaerial Erosion.

By Horace Woollaston Monckton, F.L.S., F.G.S.

On the excursion of the Geologists Association to Gower last Easter our Director, Mr. R. H. Tiddeman, showed us a series of examples of the celebrated raised beach, and a good deal of discussion arose as to its relation to the other recent deposits of the district. Into those questions I do not propose to enter on this occasion, but will accept, what all admitted, viz., that the beach is an old sea beach, that the platform upon which it rests is the work of the waves, and that it has been raised to its present position by earth-movement.

The platform is formed of solid rock, Carboniferous limestone, which for the most part dips at a very high angle, so that the old beach rests upon the upturned edges of the strata. We were shown one particularly interesting example between Caswell Bay and Brandy Cove; there the rock platform is some 20 feet above the present beach.

Its top is fairly level, but a transverse section would probably show a dip seawards. The old beach has become consolidated into a calcareous breccia, and rests on the platform, which has been somewhat eroded in places, so that in one place the beach projects beyond it. Close by, Mr. Tiddeman drew our attention to a rounded knob of rock rising a few feet above the platform, which had no doubt stood out above the shore and projected through the old beach. The irregularities of the platform under the beach are no doubt largely due to the fact that it is limestone and subject to decay underground. In one locality on the coast to the left of the estuary near Penard Castle our Director showed us a place where the platform is overlain by, and consequently protected by, a considerable thickness of beach

[1] "On the Chalk of Yorkshire": Proc. Geol. Assoc., 1878, vol. v, p. 232.

and rubble. I noticed the surface was then much more regular, the line cutting through both limestone and calcite very evenly.

We may therefore describe the platform as a tolerably level plain, with here and there knobs of rock projecting above it, and it is most instructive to compare it with the shore in front of it. The sea is now taking another slice off the upturned limestone beds. Gradually the old beach is removed, then the old platform is worn into a collection of jagged points, and these are by degrees planed away, and a new and fairly flat rock floor is cleared with a slope seaward. Still, some parts take longer to wear away than others, and knobs of rock stand up in places. What the width of the old beach may be I do not know, perhaps no wider than the modern platform in front of it.

View of Cliff between Caswell Bay and Brandy Cove, looking East.

* Here a portion of the Raised Beach projects.

† Knob of Carboniferous Limestone rising above Raised Beach.

I was more especially interested in these platforms as I have some acquaintance with a similar feature on a very much larger scale on the coast of Norway. It was described by Dr. Hans Reusch in the Year Book of the Norwegian Geological Survey for 1892–93 (Kristiania, 1894), and I have since had opportunities of examining parts of it.

The coast plain, as Reusch terms it, extends along most of the coast. Like our Gower platform it is cut in solid rock; it runs like a shelf along much of the mainland, and forms many an island. In the case of other islands it runs all round them, producing an appearance which has been compared to a hat floating on the sea, crown uppermost, hence such names as Torghatten ('market hat').

The coast plain is usually but little elevated above the sea, and rises towards the land to a height which varies in different places. Dr. Reusch thinks its topmost limit is about 300 feet. Its surface is rounded and ice-worn, and he places the date of its formation either before the Ice Age, or during intervals in that period when the coast was free from ice.

The coast plain is particularly well seen near the mouth of the Hardanger Fjord. Mountains and low hills rise sharply above the flat, which is dotted with houses and farms. At first sight this flat might be taken for sand or gravelly shore deposit, but walking over it one finds that it is solid rock with but little superficial accumulation. This flat belongs to the coast plain. In most cases it looks flatter from the deck of a boat than when one is upon it. In fact, there are many hummocks like the one Mr. Tiddeman showed us on the old Gower platform. There are also valleys no doubt excavated since the coast plain rose above the sea.

Most of the towns of the Norwegian coast stand on the coast plain, and I may take Bergen as an example, since I know it well myself, and it is probably also known to many of my readers. Bergen is for the most part built on solid rock, the Bergen Schist. The rock is worn into irregular hummocks, with a tendency to a N.W. and S.E. trend. One of these projects between the two harbours forming the Nordaes; on its top stands the old fort Fredriksborg, nearly 100 feet above the sea. Rock is seen all around the fort and out to the end of the peninsula. Inland the rock slopes downwards, and there is a flat space known as the meadow (Engen), on both sides of which fairly steep streets run down to the sea.

On the opposite side of the harbour to the north another knob of rock bears the fort Sverresborg, and to the south a smaller knob forms Sydnaes. This irregular rock surface is all coast plain, and it is sharply marked off from the mountains which rise from it very abruptly on both sides. Inland the valley between the mountains continues, and in it are some small lakes; probably when the sea stood at the level of the coast plain this was a 'sund,' and the mountains south-west of Bergen formed an island.

The coast plain is well marked around Os, south of Bergen, and there, as in many other places, I noticed how abruptly the higher hills rise from a flat rock coast plain.

Dr. Reusch remarks that all the way from Stavanger northwards to Aalsund the coast plain is for the most part bare rock, without any covering of loose material. He gives a few exceptions, such as the brickfields near Bö on the east side of the north of Karm Isle, a tract round Fitje Church on Storen, and the Isle of Herlö north of Bergen.

Around Aalsund, he says, there is a good deal of glacial gravel. At the same time, as I saw myself, a good deal of rocky coast plain is exposed near and north of Aalsund.

The coast plain of Norway, like the raised rock platform of Gower, is, I take it, a base-level of marine erosion, and is evidence that the sea at the time of its formation stood higher or the land lower than it does now. The probability is that it is the level of the land which has altered, for though the old coast plain is now above the sea along nearly the whole coast, it is believed by Reusch to have been depressed below sea-level in the neighbourhood of

Statland. The well-known headland there rises sheer from the sea, but he remarks the steep slope does not go far down under water. The fishery charts show that the 50 fathom line is from 2 to 3 miles from the land, and in that distance there are sunken rocks rising to, or nearly to, the surface, that is to say, they belong to the coast plain now under water.

In the north of Norway Dr. Reusch notes that the coast plain is duplicated. He more especially refers to the tract around Torghatten, the celebrated island, the mountain upon which has a hole through it. There we see two coast plains, the upper with a level of about 300 feet and the lower forming the usual flat stretch a little above the sea. We should get a similar result in Gower if further elevation were to take place now, for the present sea-shore would form a second raised platform, and the sea would then begin to cut another slice off the rocks at its new level.

It is not easy, in most cases, to prove by any definite evidence whether a tract of surface is the result of marine erosion or has been produced by subaerial denudation. The platform upon which the Gower raised beach lies is clearly the work of the sea, and I think Dr. Reusch has established the coast plain of Norway as being the work of the sea too, though it has no doubt been somewhat modified by subaerial denudation, and more especially by ice-action since its elevation. On the other hand, it has been found possible to prove that the wide flat plateaux of South and East Berkshire and the neighbouring parts of Surrey and Hampshire are the work of subaerial eroding agents. They are largely covered by sheets of gravel, which has been proved by its peculiarities of composition to be gravel of different rivers (Q.J.G.S., 1892, vol. xlviii, p. 29). In fact, these flat Berkshire and Surrey plateaux were the bottoms of valleys at the time of the deposition of the gravel which caps them, and the gravel being harder than the sides of the valleys has better resisted the agents of denudation.

That it is possible to produce definite evidence in this case is, however, due to conditions which do not hold in all places. Thus the valleys of the country around London are, to a large extent, newer than the Drifts which lie at high levels around them, and to a large extent the Drifts have either survived or are newer than the Ice Age. In many parts of England the surface of the solid geology is hidden by great accumulations of Glacial Drift, and in mountainous regions, such as North Scotland and Norway, the rock surface has been swept clear of all soft deposits by ice, and we have only the beds of gravel, sand, clay, etc., which have been left by, or have accumulated since, the retreat of the last glacier or ice-sheet.

The district at the head of the Hardanger Fjord, in Norway, has especial attraction for me. It is, for one thing, not yet free from ice, and a snowfield, the Hardanger Jökl, covers a considerable tract. In the second place, the main surface features seem to be the result of subaerial denudation. Dr. Hans Reusch has quite recently dealt with this question in the Year Book of the Norwegian Geological Survey for 1900 (Kristiania, 1901), and I am much interested to

find that he is even more subaerial—if I may use such an expression—than myself. The best known of the valleys at the head of the Hardanger Fjord is that leading up to the celebrated waterfall, the Vöringfoss. At the top of the fall is the Fosli Hotel, and if we mount up to it we find ourselves upon a wide stretch of moorland with rounded hills and wide open valley, through which flows the River Bjoreia. Whatever may have been the origin of this surface it has been clearly modified by ice-action, for all the rock surfaces are smoothed and rounded and erratic blocks abound. I noticed one boulder of coarse granite, 6 feet high, on the moor, and there are many others of considerable size. How long a time may have elapsed since these boulders were brought to this spot I cannot say, but the perpetual snow probably covered the ground in quite recent times, for the Hardanger Jökl is only some 8 miles away to the north-west, and I believe only about 2,300 feet above Fosli, the level of which is about 2,200 feet. There is a good deal of peat on the moor, and it looked thick in places, but I could find no other superficial deposit. Though there is a general rounding of the outlines of mountain and valley here, I could see nothing which suggested a platform of marine denudation like the Norwegian coast plain. There seemed no point of which one could say, "Here the mountain rises abruptly from the plain," as one so often can in the case of the coast plain. It is true the notch of the old margin might have become full of talus, but with the exception of the slopes of one mountain, Gryteſjeld, there seemed very little talus. On the whole it seemed to me that these valleys were the result of subaerial denudation. In this I find Dr. Reusch concurs, and he classes this moorland as belonging to what he names the Palæic surface of Norway. So far as Norway is concerned he is disposed to define this surface as the surface which existed with its principal features before the Quaternary Period, and thus the surface of Tertiary or even older times.

If I am right in thinking that the gravel of Chobham Ridges, in Surrey, is a river gravel of the earliest Glacial or even of Pliocene date (Q.J.G.S., vol. liv, p. 193), then the surface upon which it lies is a bit of the Palæic surface of England, the bottom of a Palæic valley in fact. In Norway, where the rocks are hard, we have the Palæic hills and valley, with its river still flowing through it, the whole, no doubt, much modified by ice-action. In Surrey, though there was no glacier so far as we know, the floods, etc., of the Ice Age have almost removed the old surface, leaving only the bottom of the valley where it was protected by river gravel.

The old land surface of Hardanger stands now some 2,000 and more feet above the sea, and in it a series of narrow and deep valleys have been cut out, and into these valleys the rivers flow to the fjord. Thus the Bjoreia, after flowing in the broad open valley of the old surface, suddenly falls 500 feet into the head of one of these deep valleys (Maabodal), the fall being the Vöringfoss. To the north the next stream of any size falls over the steep side of the Simodal as the Skykjedals fall, and the next into the head of the same dale

as the Rembesdals fall. Returning to Surrey, we find that something also occurred there, for the river which had deposited the Chobham Ridges Gravel, now at a level of 400 feet above the sea, appears to have deepened its valley and deposited the sheets of gravel on the side of the Fox Hills, now at a level of about 250 feet. Dr. Reusch suggests that the result in Norway was produced by a rise of the land, and I have made a similar suggestion with regard to Surrey ("Origin of the Gravel-Flats of Surrey and Berkshire," GEOL. MAG., N.S., Nov. 1901, Dec. IV, Vol. VIII, p. 510).

I will leave the valleys, however, and return to the high ground of Hardanger. To obtain a general idea of it let us ascend one of the mountains on the north of the Fjord, say one of those above Norheimsund; then looking south and south-east across the fjord we see the long flat snowfield, Folgefond, stretching above all along the skyline. To the left the top is a little lower and merely dotted with snow patches, one prominent summit, Haarteigen, standing above the general level to about the height of the snowfield. A little to the north, but hidden by nearer mountains, is the Hardanger Jökl snowfield, also rising above the mountain-tops around it. Now what are we to say about this, the topmost plain of the country? Is this a plain of marine erosion, or have we in it another old plain of subaerial denudation, or peneplain as some authors would term it? Dr. Reusch decides in favour of the latter explanation. He says (p. 131), "The high mountain expanses of Norway are most likely, as a rule, peneplains—I do not say a peneplain, for probably they do not all belong to the same geological time. . . . . One district where this can be exemplified is, for instance, the high mountain region north and north-east of the Hardanger Jökl. Above the open stretches, where the saeters are, there rise higher plateau-shaped mountains the surface of which seems as though it were the remains of another and older peneplain." Thus we have Hallingskarven, 1,951 metres; Hardangerjöklen, with about the same altitude; Bleien, 1,696 metres; Blaaskavlen, 1,773 metres, etc. And he gives (p. 134) a map on which he marks these and other plateaux, as well as Haarteigen and the Folgefond, as remains of the older peneplain. He adds that the level of the highest plateau seems to be independent of the geological rock formation; thus it rises above the line where we have a tolerably horizontal boundary between the Grundfjeld (mostly gneiss) and the Cambro-Silurian schists.

I refrain from going further into the question now, and content myself with the remark that I think Dr. Reusch has clearly shown that an alteration in the level of the sea almost of necessity causes changes of the land surface, which extend far inland, and the commencement of a new land surface at a new level; and if this is the case amongst the hard rocks of Norway, how much greater must be the effect of a change of sea-level where the inland rocks are soft as in the south of England!

VIII.—A Geologist of the last Century.

Dr. Ferdinand von Roemer, the Father of the Geology of Texas: his Life and Work.[1]

By Frederic W. Simonds, Austin, Texas.

(WITH A PORTRAIT, PLATE XIX.)

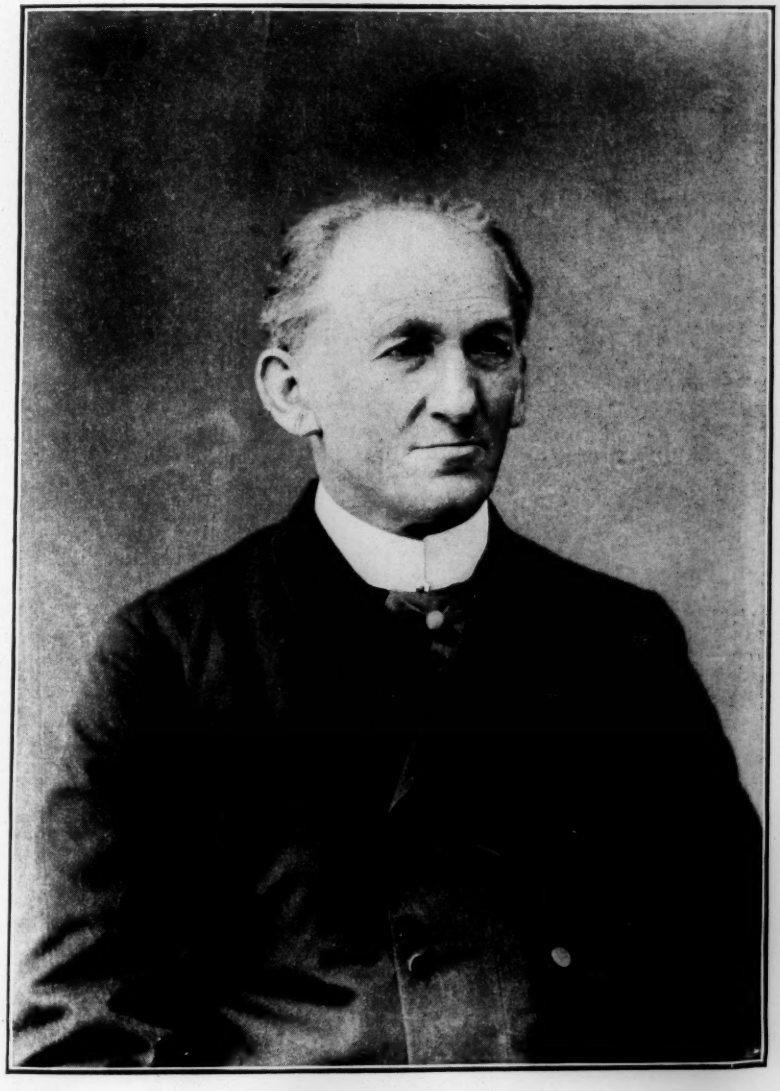
FERDINAND ROEMER, who has justly been called the "Father of the Geology of Texas," was born at Hildesheim, Hanover, on January 5th, 1818. His early education was obtained at the Gymnasium Andreanum of that town, where, under the influence of his teacher, Dr. Muhlert, he developed a great fondness for science, especially in the line of natural history. His love of geology, however, was strongly developed by excursions with his eldest brother, F. A. Roemer, Frederic Hoffmann, and F. A. Quenstedt. Notwithstanding his predilection in this direction, he was induced by his brother, probably with the view of entering a well-established profession, to undertake the study of law. Accordingly, from 1836 to 1839 he was engaged in attending legal instruction at Göttingen, with the exception of the Summer semester of 1838, which was spent at Heidelberg. Still, the attraction of science was well-nigh irresistible. With the keenest pleasure he listened to Hausmann on geognosy, and when at Heidelberg the zoological instruction of Bronn was eagerly sought. His future calling was, however, to be decided in favour of his natural bent. As he was about to present himself for examination in the higher legal course, for political reasons — although he himself was an innocent party — certain difficulties were raised and he withdrew. Thus science gained a brilliant scholar and geology a zealous investigator.

Going to Berlin (1840) he came within the influence of such men as Weiss in mineralogy, von Dechen in geology, especially that of Germany, Gustav Rose in geognosy and mineralogy, Mitscherlich and H. Rose in chemistry, von Lichtenstein in zoology, Johannes Müller in anatomy and physiology, Dove in physics, and Steffens in anthropology.

On May 10th, 1842, he received the degree of Doctor of Philosophy, having presented a palæontological dissertation entitled "De Astartarum genere et speciebus quae e saxis iurassicis et cretaceis proveniunt."

The time spent at Berlin had an important bearing upon his future in still another direction. It was here that an intimate friendship sprang up between him and von Dechen, Beyrich, and Ewald, and his intercourse with them led, on his part, to a wider comprehension of geology and a better understanding of the methods to be pursued in research. About this time he became engaged in a series of investigations in the Rhenish mountains which covered the Summer season of several years. The results of this work were published in 1844, under the title "Das rheinische Übergangsgebirge. Eine palaeontologisch-geognostische Darstellung." The

[1] Reprinted by kind permission of the Editor, Dr. N. H. Winchell, from *The American Geologist*, vol. xxix, March, 1902.



Yours very sincerely

F. Ferd. Roemer

next year (1845) his first contribution to the *Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie* appeared, and thereafter for more than forty years his name was familiar to the readers of that journal.

He now (1845) entered upon that part of his career which is of the greatest interest to Americans, especially Texans. With means provided in part by the "Berliner Akademie der Wissenschaften," and with the warm personal endorsement of the celebrated traveller and explorer, Alexander von Humboldt, he undertook a journey to America for the purpose of studying its geology and palæontology, in the course of which he spent a year and a half in the then little known state of Texas. Here, to judge from the results of his investigations, his activity must have been very great, for, in addition to contributions furnished to the American Journal of Science and Arts in 1846 and 1849 (ser. II, vols. i and vi) and a more popular work entitled "Texas. Mit besonderer Rücksicht auf deutsche Auswanderung und die physischen Verhältnisse des Landes," published at Bonn in 1849, he gave to the world in 1852 "Die Kreidebildungen von Texas und ihre Einschlüsse. Mit einem die Beschreibung von Versteinerungen aus paläozoischen und tertiären Schichten enthaltenden Anhange und mit II von C. Hohe nach der Natur auf Stein gezeichneten Tafeln," printed also at Bonn, by Adolph Marcus. It was this work that won for him the title "Father of the Geology of Texas." That Roemer should have been able to accomplish so much during his brief sojourn in the state is remarkable considering the limited means of transportation and the serious danger from wandering bands of Indians when conducting scientific work outside of the immediate vicinity of the settlements. Under such circumstances, that his results should have been so accurate is little short of phenomenal.

Before proceeding farther it may be well to direct attention to some of the salient points brought out by these early investigations. "Die Kreidebildungen" is not entirely devoted to the Cretaceous or Chalk formation of Texas, for, in addition to a detailed consideration of that formation and its fossils, the introduction treats of such topics as the following: "Geographic Position and General Orographic Character of Texas," in which the greater topographic features of the state, with the exception of the western mountains, are clearly described; "General Geognostic Constitution of the Land"; "Diluvial and Alluvial Formation"; "Tertiary Formations"; "Older or Palæozoic Strata"; and "Plutonic Rocks." The Appendix, moreover, contains descriptions of fossils from the Palæozoic strata and descriptions of fossil woods by Professor Unger. In view of the above outline it scarcely need be said that this work has been a fruitful source of inspiration to all who have made a special study of the topographical and geological features of this region. That it, as well as the earlier descriptive volume, should not have been translated into English long ago, is somewhat remarkable. Concerning the geological map in the earlier volume, based upon Wilson's geographical map, it is fair to say that the general

features of the state are well shown and with an unexpected degree of accuracy.

But Roemer's American studies were by no means confined to Texas. In 1860 he published "Die Silurische Fauna des Westlichen Tennessee; eine Palaeontologische Monographie," with five plates.

In June, 1848, he became Privat Docent in mineralogy and palæontology at Bonn. That his studies in Texas were still uppermost in thought is apparent from the title of his probationary discourse, "Eine übersichtliche Darstellung der Geognostischen Verhältnisse von Texas." His natural gifts as a teacher rendered possible, in 1855, the call to an ordinary professorship in the University of Breslau, in connection with which he became Director of the mineralogical cabinet. Here he found a few minerals, scarcely sufficient to meet the needs of instruction in a realschule, stored away in most inaccessible quarters. At once he determined to undertake the laborious task of making a great collection. How well he succeeded is shown by the fact that he left to his successor one of the richest and best arranged collections of minerals and fossils in any of the Prussian universities.

In 1861, to the great satisfaction of his colleagues and friends, he declined a flattering call to Göttingen. Five years later, in 1866, his fidelity and labour were rewarded by the removal of his collections into a new and commodious building, erected largely after his own plans, on the Oder, between Schuhbrücke and Universitätsplatz. In arranging the collections in their new apartments Dr. Roemer was ably assisted by Oberbergrath Martin Websky, who under his influence soon resolved to devote himself entirely to science, becoming first extraordinary professor at Breslau and later the successor of Gustav Rose at Berlin. It was not a small matter to have discovered such a man. But his influence with his students was also great, for on the list of those who, under the inspiration of his teaching, took upon themselves science as a life-work we find such names as H. Credner, W. Dames, K. Hintze, Cl. Schlüter, Th. Liebisch, H. Eck, K. von Seebach, T. Tietze, and others who have gained recognition in the learned world. Indeed, no better evidence of his unusual power as a teacher is needed. Says one of his students: "His love of teaching, his ready utterance, his kindly care for his pupils, remained unchanged to the end. When well advanced in years he taught with the same zeal, the same vivacity, and the same clearness that characterized his work when a young man."[1]

While his activity in the routine duties of his professorship was very great it was not less in the direction of research and investigation. In the *Neues Jahrbuch f. Min. Geol. und Pal.* Dr. Dames has listed over 350 titles of publications in the interval between his graduation, in 1842, and his death in 1891, many of which represent long and patient investigations. While it would not be possible within the limits of this sketch even to mention all the subjects covered, for they are of wide range, attention may be called to

[1] Dames.

a few other than those already alluded to in the preceding pages. During the years 1852–1854 he published in connection with its author a revision of H. G. Bronn's "Lethaea geognostica oder Abbildung und Beschreibung der für die Gebirgs-Formationen bezeichnendsten Versteinerungen. Bd. i, 2: Palaeo-Lethaea; Kohlen-Periode (Silur, Devon, Kohlen- und Zechstein-Formation)." More than twenty years later we find him again engaged upon an enlarged and revised edition of this work. The atlas, with 65 plates, appeared in 1876; in 1880 the first part of the text, and in 1883 the second part. It is a matter of regret that he did not live to complete this undertaking. In 1861 he published "Die Fossile Fauna der Silurischen Diluvial-Geschiebe von Sadewitz bei Öls in Niederschlesien." This was in the form of a "Gratulationsschrift" of the Silesian Society to the Breslau University at its jubilee held that year.

In July, 1862, the preparation of a geognostic map of Upper Silesia on the scale of 1 : 100,000 was authorized by the Prussian Ministers of Commerce, Trade, and Public Works, and Roemer was selected to direct its construction. For eight years, assisted by O. Degenhard, H. Eck, and A. Halfar, he devoted himself to this work, and at the same time made numerous short contributions announcing new discoveries in the geology and palæontology of that region. These served as forerunners of the "Geologie von Oberschlesien," a work in three volumes, published in 1870, which contained the complete results of the investigations of himself and his assistants. The great value of this publication is evident when we take into consideration that up to this time little was known of the geology of the province, which had long been famous for the value of its mineral deposits.

After the publication of this work he found time not only to rewrite portions of "Lethaea Palaeozoica," to which reference has already been made, but to prepare numerous smaller contributions treating of his investigations and studies, among which may be found the first observations upon the discovery of diluvial mammals in the low plain of Northern Germany, especially in Silesia and Poland. So great was his interest in this direction that later he undertook an investigation of the Polish bone caves, concerning which he published in 1883 a large work bearing the title "Die Knochenhölen von Ojcow in Poland" (Palæontographica, xxix). This was translated into English by John Edward Lee, under the title "The Bone Caves of Ojcow in Poland," and published the following year in London.

As further evidence of Roemer's great activity, it may be remarked that he had already prepared and published (1880) a description of the Carboniferous Limestone fauna of the west coast of Sumatra—"Uber eine Kohlenkalk Fauna der Westküste von Sumatra" (Palæontographica, xxvii)—based upon a fine collection sent him in 1876 by Verbeek.

In 1885 appeared "Lethaea erratica" (Palaeont. Abhand. von Dames u. Kayser, Bd. ii, 5, Berlin), embracing an enumeration and description of the boulders occurring in the North German plain.

Among his papers published in 1887 is the description of a fossil Crustacean from the Shoal Creek region near Austin, entitled "*Graptocarcinus Texanus*, eine Brachyure aus der oberen Kreide von Texas," with an illustration (N. Jahrb. f. Min., etc., 1887, Bd. i, 173). The next year he published the description of "*Macraster*, eine neue Spatangoiden-Gattung aus der Kreide von Texas" (N. Jahrb. f. Min., etc., 1888, Bd. i, 191), represented by *M. Texanus* from Georgetown. The same year he also published "Uber eine durch die Häufigkeit Hippuriten-artiger Chamiden ausgezeichnete Fauna der oberturonen Kreide von Texas" (Paleont. Abhand., Bd. iv, 3 plates). The fauna here considered is from Barton's Creek, a well-known locality a short distance south-west of Austin. Of the twenty-one species described he regarded eighteen as new. Objection has been justly taken by the students of Texan geology to the assignment of this fauna to the Upper Turonian, for, as a matter of fact, the strata are Lower Cretaceous, and cannot be correlated with that formation.

But Roemer was a mineralogist as well as a geologist and palæontologist. In a practical way this was shown in his great work at the Breslau Museum. His love for minerals was strong, and his knowledge such that he was envied by the younger men who specialized in that line. It has, however, been said that his greatest service to mineralogy was that he "saved" to that science the incomparable Websky.

Again, Roemer was a man of wide experience in travel. Not only did he visit North America, but in Europe every country and some countries several times; England in 1851, 1866, 1871, 1876, and 1880; Ireland in 1883; Holland and Belgium in 1854; Sweden in 1856 and 1878;[1] Austria and Upper Italy in 1857; Piedmont and Bohemia in 1858; Norway in 1859; France in 1860; Russia in 1861; Turkey in 1863; Spain in 1864 and 1872; Switzerland in 1869. These journeys, his numerous publications, and an unusual aptitude in acquiring foreign languages, made him probably the best known German geologist of his time.

As would naturally be expected, his long and active career brought him many honours, both at home and abroad. In recognition of his great service to science he was invested with a title by the State, and elected to membership in many of the learned societies, among which may be mentioned the Geological Society of London, 1859; the Royal Academy of Science, Berlin, 1869; the Imperial Academy of Science, St. Petersburg, 1874; the Royal Bavarian Academy of Science, Munich, 1885. In the year last mentioned he was also the recipient of the Murchison Medal of the Geological Society.

[1] It was Dr. Woodward's good fortune to know Dr. Ferdinand Roemer for many years (from 1858 to nearly the end of his life). Travelling on a geological excursion in the Eifel with Mr. John Edward Lee, F.G.S., in the Autumn of 1878, they met, quite accidentally, Dr. Ferdinand Roemer near Gerolstein, and with him as geological guide and most genial of companions, they spent a never-to-be-forgotten fortnight, visiting with their historian all the most interesting Devonian fossil localities, and examining the extinct craters (now crater-lakes) in that delightful country. In the following year Mr. Lee and Dr. Roemer made an expedition to Faxe in Denmark to study this very interesting uppermost Cretaceous deposit.—Edit. Geol. Mag.

Roemer's knowledge was not, however, entirely confined to science, though its range here was surprisingly great; he was also well informed in the classics and *belles lettres*. His nature was winning, his manner attractive, and his influence with the young great. It scarcely need be said that he had many friends and admirers. Although happily married for twenty-three years he was childless, yet his love of children was shown in the rearing of his wife's nieces as his daughters.

It was his great good fortune to be able to look back upon a life rich in opportunities and fruitful in results. He had expressed the hope that the end might find him in the full possession of his powers rather than burdened with the infirmities of old age, and his wish was granted. He died at Breslau on December 14th, 1891, in his 74th year.

NOTICES OF MEMOIRS, ETC.

1. Canada (?).—"A Summary Report of the Geological Survey Department for the Calendar Year 1901, printed by order of Parliament, *Ottawa*, 1902," has reached us; but nowhere in the title do we discover its country of origin. From internal evidence, however, we gather it comes from Canada. The report is full of interesting matter, contains two new *Trionyx*, illustrated, from the Cretaceous of Alberta, but suffers from the want of an index, or at least chapter headings. In these busy days 269 pages of Report are apt to be considered as mere Report unless the reader is furnished with a clue to the contents.

2. Pyrenean Volcanoes.—Patrick W. Stuart-Menteath describes the volcanic phenomena of the Pyrenees in a series of papers published in the Boletin de la Sociedad Aragonesa de Ciencias Naturales (Zaragoza), a new serial of which we have seen No. 5 of vol. i (May, 1902).

3. The German Geological Society.—Dr. E. Koken has published (Berlin, 1901) "Die Deutsche geologische Gesellschaft in den Jahren 1848–1898, mit einem Lebenabriss von Ernst Beyrich," with a portrait of Beyrich. It is interesting to recall the names of the founders of the German Society—von Beust, Beyrich, von Buch, von Carnall, Ehrenberg, Ewald, Girard, von Humboldt, Karsten, Mitscherlich, J. Müller, Rose, Weiss.

4. Maryland.—The fourth volume of the Maryland Geological Survey (*Baltimore*, 1902) deals with "Palæozoic Appalachia, or the History of Maryland during Palæozoic time," by Bailey Willis. This is a highly interesting physical and dynamical paper, and is well illustrated. A second report on Highways by Messrs. Reid & Johnson contains results of tests of road materials and technical notes on road construction. Heinrich Ries contributes a long report on the Clays of Maryland, both from a geological and economic point of view. We again recommend the get-up of this publication to the notice of the Geological Survey of the United Kingdom.

5. The Conflict of Truth.—This is a book by Mr. F. Hugh Capron, apparently written to reconcile Religion and Science. To those who are interested in this matter these 509 pages of argument may prove more absorbing at this time of year than throwing pebbles into the sea. There are chapters on "the six days of the formation," "the antiquity of man," and divers other matters. Publishers, Hodder & Stoughton, 1902; price 10*s.* 6*d.*

6. A New Meteorite.—Mr. Geo. P. Merrill describes some 20,000 grams of meteorite which fell at Admire, Lyon County, Kansas, probably 30 years ago. It is a pallasite and belongs to Brezina's Rökicky Group, consisting of metallic iron and olivine.

7. Tarcoola.—The Record of the Mines of South Australia, issued by H. Y. L. Brown in 1902, deals with "Tarcoola and the North-Western District." The report is concerned mainly with the goldfields. The mass of the country consists of Cambrian (?) and metamorphic rocks, with Tertiary conglomerates and gravels, but there are gypseous clays at Lake Cadibarrawirracanna. A geological sketch-map is appended.

8. Foraminifera.—Among the recent publications on this group may be mentioned Rhumbler's important paper on the double shells of *Orbitolites* and other foraminifera, with excellent illustrations, published in the Archiv für Protistenkunde, 1902. The author deals with and endeavours to explain the curious 'twinning' so common in *Orbitolites*. Messrs. R. B. Newton and R. Holland describe in the Journ. Coll. Sci. Tokyo, 1902, Bryozoa and Foraminifera from the Formosa and Riu-Kiu Islands; there are four plates, chiefly rock-sections showing organisms, and a figure of an *Operculina* which appears to have been an inch in diameter. Schlumberger (Bull. Soc. géol. France, 1901) figures *Orbitoides media*, d'Arch., and other forms of the genus, and discusses the genus in general; in another note (Samml. Geol. Reichs-Mus. Leiden, 1902) he describes a remarkable quadristellate *Lepidocylina* from Borneo. Barrois records the genera *Endothyra*, *Textularia*, *Lagena*? and *Valvulina*? from the Carboniferous phtanites of the Boulonnais (Ann. Soc. géol. Nord, 1902); and Lomnicki mentions the occurrence of *Globigerina* and *Sphæroidina* in the Miocene sands of Léopol (Kosmos, Lemberg, 1902). Fornasini, ever busy in this group of animals, has papers on three species of *Textularia* and a *Polymorphina* founded by d'Orbigny in 1826, a continuation of his valuable notes on forms described but not figured hitherto; on O. G. Costa's *Faujasina*; on the date of publication of Costa's "Foraminiferi di Messina"; and on the nomenclature of "*Nautilus* (*Orthoceras*) *pennatula*" of Batsch: all these papers appear in the Rivista Italiana di Paleontologia for 1902. Schubert discusses Defrance's genus *Textularia*, and with Liebus records foraminifera from the Devonian (Etage G–g_8, Barr.) of Bohemia (Verh. k.k. geol. Reichs., 1902).

9. Ostracoda of the Basal Cambrian Rocks of Cape Breton.[1]—Dr. G. F. Matthew has described a considerable number of species

[1] Canadian Record of Science, 1902, vol. viii, No. 7.

of Ostracoda, and three new genera from the rocks older than the Paradoxides Beds but included in the Cambrian system. The author claims that these forms differ in many respects from the species of the Ordovician system, and have a unity of structure sufficient to place them in a new family distinct from Leperditiidæ, etc. Many of the species have wide valves, more or less pointed on the ventral margin; most have long hinge-lines and an ocular tubercle. The scar of the adductor muscle, in place of being near the middle of the valve as in many Ordovician species, is close to the anterior end of the cardinal line. Twenty-seven forms are described, arranged as follows: — *Leperditia* (?), 1 species; *Bradorona* (subgen.), 3 species, 8 mutations, and 1 variety; *Bradoria*, 3 species and 1 doubtful, 1 mutation; *Escasona*, 1 species and 2 doubtful; *Indiana*, 2 species and 1 mutation; *Schmidtella* (?), 2 species and 1 mutation. Two of these forms are found in the basal volcanic terrane of Coldbrook; the rest are distributed through 500 feet of the Etcheminian terrane, occurring in twelve assises of that group in company with various Brachiopods. Two plates accompany this article in which are figured the various species and mutations described. Outline figures are also given to show the more obvious characters of the new genera.

REVIEWS.

I. Etude Géologique sur l'Isthme de Panama; par MM. Marcel Bertrand et Philippe Zurcher. II. Les phenomènes Volcaniques et les Tremblements de Terre de l'Amérique central; par M. Marcel Bertrand. Quarto; pp. 38 in all, with plans and sections; published 1899.

I.

THE long-standing controversy between the advocates of the Panama route and those of the Nicaragua route for the great American interoceanic canal has apparently at the last moment been decided in favour of the former. Apart from the struggles of politicians this decision seems to be by far the most sensible, since property which even in its present state is worth something like £8,000,000 sterling must of necessity represent an asset of considerable value. It would seem not altogether improbable that the recent catastrophe in the Windward Islands has had its due effect in impressing upon the politicians at Washington the possible dangers of the Nicaragua route, which were so forcibly pointed out by Professor Bertrand in these memoirs more than three years ago, dangers foreseen by nearly all scientific men, and whose lessons just at present are well burnt into the mind of the Transatlantic public.

Since the time when the second great work of Mons. de Lesseps was commenced a new generation has appeared upon the scene, but it may not be without interest on the present occasion to quote a portion of an article which appeared in *Nature*, August, 1885,

entitled "Piercing the Isthmus of Panama," an article evidently written in an optimistic spirit which is rather amusing in the light of subsequent events. It commences as follows :—

"Three years ago the work of cutting through the Panama Isthmus had barely commenced. The equatorial forests on the neck of land, 73 kilometers long, which marked the axis of the future interoceanic canal, had hardly been laid bare. The traveller who followed the primitive road met here and there some groups of cabins with roofs of branches on poles, marking the site of a sounding or the improvised dwellings of a portion of the operators. Culebra, Emperador, Corosita, and Gamboa, which are now full of activity, were then almost desert, and on the coast of Colon alone the excavator traced in the marshy plains of Gatun his great track. The contrast to-day is great: a long file of workshops covers the space between the Atlantic and the Pacific. Twenty thousand workmen toil on the Cordillera, making the deep cutting for the canal. Side by side with this army, another more powerful army of colossal machines, excavators, dredges, locomotives, waggons, all the materials for transport, thousands of pairs of wheels, hundreds of kilometres of sails, mountains of coal, and shiploads of dynamite. Among the twenty-five workshops of the peninsula the attention is chiefly attracted to two points : the great rocky cutting at Culebra, which is to penetrate to a depth of 120 metres into the Cordillera, and the dam of the Chagres at Gamboa. At Culebra the previsions of M. de Lesseps have been realised : the mountainous mass which the canal will traverse is, for the most part, composed of rocks which are not very hard ; repeated soundings by means of diamond perforators have shown that down to a considerable depth the rock takes the form of schists [*sic*] in horizontal strata. There is no doubt that it can be cut through with rapidity ; it is a matter of perforation, either by mining and ordinary explosives, or by shafts with larger quantities of some explosive to displace great masses. Here 30,000 cubic metres of rock have been displaced by an explosion of dynamite ; and unquestionably this colossal channel connecting two seas may be executed by simple methods and with economy."

The article from which the above extract is taken was probably written by an engineer rather than by a geologist, but the writer gives us an interesting picture of work then going on, *and we may shortly expect to see such work renewed to the finish.*

Meanwhile, it will be convenient to consider the geological aspects of the question as set forth in the two short though important memoirs to which Professor Bertrand has mainly contributed.

In dealing with the subject of previous publications the authors state that the actual base of our knowledge of the age of the beds of Panama is to be found in two notes published by M. Douvillé in 1891 and 1898. The first of these notes was founded on the examination of a series of fossil specimens collected by M. Canelle, a former engineer of the Canal Company. The second, of which a *résumé* only has already appeared (December, 1898), has had for

its starting-point the study of the fossils brought by M. Zurcher. The authors also refer to the works of Messrs. Hill, Dall, Wagner, and Boutan in this connection.

The Panama memoir is illustrated by two coloured sections—one a general section of the whole 74 kilometres of the canal; the other, on a larger scale, of the great cutting (Emperador and Culebra) between the 48th and 56th kilometres. The range in time covered by these sections extends from the Tongrian with Nummulites to the Quaternary, the Aquitanian and Miocene being represented, but the Pliocene being absent.

General Structure of the Isthmus: Rock of Gamboa.—The oldest formations occur in the centre of the Isthmus, where their outcrop forms a large undulating plateau; these pass under more recent beds on both sides, the general arrangement being a very flattened anticline. The central part is formed by a volcanic rock—the rock of Gamboa, which is described as consisting of breccias and lava-flows, with which at the northern end is associated a bank of Nummulites. Whether we regard the rock of Gamboa as of 'Tongrian' or 'Aquitanian' age (i.e. Oligocene), it represents the most ancient formation of the Isthmus. Wagner has spoken of Permian grits on the Pacific coast, but these are merely trachytic tuffs and breccias reddened by decomposition. Mr. Hill has endeavoured to assign to these same tuffs a Cretaceous age; we shall see, however, that they are clearly superposed on the rock of Gamboa, and even on Miocene fossiliferous limestones.

The Atlantic Slope.—Taking the breccia and the associated beds with Nummulites as a datum-line, we find in the direction of Colon a series of marine beds more and more recent as we approach the coast. This series, which is perfectly continuous, contains the débris of older eruptive rocks, but without any lava-flows, and extends in time from the 'Aquitanian' to the Lower Miocene. Mr. Dall had previously determined the fossils of some of these beds as Eocene (Claiborne), but their superposition to beds with *Orbitöides* is certain. The *calcaire à Orbitöides* itself, associated with the sandstones and clays of Vamos, are regarded as *Aquitanien marin*. The highest beds on this side, excluding the Quaternary, are the *argiles de Mindi* of Lower Miocene age. The fauna, which is very rich and well preserved, represents that of the Miocene of the Antilles.

South-West Slope: Cutting of Culebra.—Passing to the other side of the central anticline, we find a series of beds almost symmetrical with the preceding, but which differ in containing brackish intercalations with vegetable matter and abundance of eruptive rocks. In the coloured section these are generalized under the heading "Tufs et gres de la Culebra (Aquitanien schisteux et lignitifère)."

The whole of this 'Aquitanian' series is pierced by the 'andesites de la Culebra' of Upper Miocene age, and the peaks of the Cerro Culebra are composed of these same andesites. Above this very extensive and varied series of beds of 'Aquitanian' (i.e. Upper Oligocene) age, there come the equivalents of the Lower Miocene of the Atlantic side, reinforced by beds of trachytic tuffs.

Pacific Slope.—Beyond the great cutting the lignite system falls below sea-level, but the limestone with *Pecten subpleuronectes* represents the same fossiliferous horizon as on the Atlantic side. The trachytic tuffs of the Pacific side are more recent than this, i.e. than the base of the Lower Miocene, an opinion, as we have already seen, opposed to the views of Hill. In speculating as to the formation of the Isthmus generally, the authors especially dwell on the slight consideration which should be attached to the difference between the marine deposits on the Atlantic side and the brackish-water deposits with lignite, leaves, etc., on the other. This they think tends to minimize the importance of the *bombement* since the Oligocene epoch.

Latest Eruptions: Dividing Ridge.—With the formations noticed above the sedimentary series of the Isthmus terminates, but the eruptions have continued since the deposition of the Lower Miocene: these last eruptions in the neighbourhood of the canal constitute the summits of the actual crest. We have already seen that they are described as andesites. It is only possible, say the authors, to fix a lower limit to the age of these rocks; they traverse in dykes the Lower Miocene, to which their flows are superposed. "But what one can say is that *they have no connection* with the recent volcanic series known in Costa Rica, Nicaragua, and Guatemala, a series of which the actual volcanoes are only the enfeebled prolongation. All observers, and especially Mr. Hill, are very explicit on this point. Now the earthquakes of the region are directly connected with volcanic eruptions; it is then an essential point to know that volcanic activity has long since been extinct in the region of Panama."

This account should not terminate without an allusion to the *argiles rouges superficielles*, which are the result of the disintegration of all the above-mentioned formations, both igneous and sedimentary, under atmospheric agencies well known in the tropics. This material occurs on the surface and covers the several formations unconformably. It functions apparently as a kind of drift and is very apt to slide, to the great detriment of the canal cuttings. A description of the Quaternary beds and alluvium follows. From the circumstance that no Pliocene beds are found on the Atlantic coast the authors infer that the sea was more distant at that period than at present. An elaborate microscopic description of the rocks concludes this memoir.

II.

Mons. Bertrand alone is responsible for the second memoir, which is illustrated by a map of the volcanoes of Central America after Mons. Sapper (Zeitschr. deutsch. Gesellschaft, 1897), and also by another map, showing the lines of folding and the lines of volcanoes in Central America. In describing the four great volcanic ranges, viz., those of Guatemala, San Salvador, Nicaragua, and Costa Rica, the author observes that these are arranged in echelon, and he is careful to indicate that the points of fracture of each of the volcanic series correspond to the lines of exceptional mobility which are marked by the existence of a lake or equivalent depression. The

lake of Nicaragua is one of these, and he observes that if volcanic activity has opened out the way for the piercing of the canal such an agent must be regarded as a formidable auxiliary. He goes on to describe in considerable detail the function of these fractures, which are transverse to the general alignment of the several volcanic ranges, and insists upon it that the four fractures of the first class, viz. those which effect the dislocation of each of the four volcanic ranges, mark the sites of the greatest instability.

The author has no doubt as to the correctness of the above generalization, but there are further conclusions of considerable interest, though not so absolutely certain. The volcanic activity of this region appears to be undergoing a change of position, and this too in a definite direction. He quotes Suess in support of this view, who considered that this shifting of position is always taking place in the direction of the Pacific. After going into the history of eruptions and earthquakes, he concludes that in the course of a few centuries since the Spanish conquest "the preponderance has passed from Guatemala to San Salvador; and, as to Nicaragua, the difference with the aforementioned states is growing less. If we add that in Mexico volcanic activity has immensely diminished since the Quaternary period, that in the preceding periods it attained its maximum much further north, along the coasts of the United States of America, we cannot fail to be most strongly struck by the significance of the preceding enumerations." If we proceed to apply this principle of shifting to the great transverse faults, which break the continuity of the volcanic chains, we perceive the same movement *en échelon* from north-west to south-east. "The transverse fracture of Guatemala has but one active volcano in its neighbourhood, viz. Fuego: it is a seismic line of diminishing intensity; its lake has scarcely a volcanic appearance; it is a fire-place on the road to extinction. Fonseca, with its girdle of active volcanoes, has had its great catastrophe in 1835: whether or no that is likely to be the last, it is a fire-place in full activity. The lake of Nicaragua is also an active fire-place; it is perhaps, as Fuchs asserts, the principal fire-place in Nicaragua; but, violent though it has been, the eruption of 1883, compared with that of Coseguina, is but an abortive eruption. *It is a warning; the catastrophe has yet to come.*"

With such a possibility in view Professor Bertrand asserts that the dangers which menace this region are by no means of a vague nature. Again, he insists that the line of Nicaragua is one of the lines of weakness and instability of Central America, the lowering of the platform being due to a transverse volcanic fracture; the same cause which creates apparent facilities for the cutting of the canal creates also a lasting danger. What has happened on the homologous site of Fonseca indicates the nature of this danger, not with absolute certainty, but with the chance of fulfilment at no distant period. He then proceeds to point out the possible results on works such as an interoceanic canal would require. What with eruptions, earthquake shocks, and seismic waves, these would have

a poor time of it, and he reminds his readers that during the earthquake of May, 1844, the waters of Lake Nicaragua rose and caused tremendous damage along its shores. Hence he issues a warning against the folly of entering into a hopeless contest with the forces of Nature.

Reverting once more to the Isthmus of Panama, Professor Bertrand points out that in the whole of the region included between Chiriqui, whose last eruption was in the sixteenth century, and Tolima, the most northern volcano of the Andean system, there are no recent volcanoes: it is a region of calm between the two Americas. As we have already seen, the latest eruptions date from the end of the Miocene period. The lowering of the platform at Panama is due, not to a transverse fracture, but to a lesser manifestation of the forces which have caused the Isthmus to rise up. "The Isthmus," he says, "is formed by an extremely flattened vault, showing in the centre flows and breccias of Oligocene age, on which repose on either side, with a slight inclination, the series of Aquitanian and Miocene beds. The eruptions, for the most part submarine, have continued intermittently to the end of the Miocene; then came the uplift, before the Pliocene, which has formed the central anticlinal of the Isthmus. This anticlinal is most conspicuous from north-west to south-east, consequently it has made its mark more strongly in the contour of the country." This is the sole cause of the natural gap of Panama. He further entertains the question of earthquakes in this district, which, when compared with those of other places in Central America, seem to be unimportant. The question of the subsidence of the Bay of Panama is discussed in connection with the hypothesis of Suess of a progressive subsidence of the Pacific coast. He concludes that there really has been a subsidence, so far as the Bay of Panama is concerned, but he does not see any indication that the phenomenon is likely to continue.

The concluding part of this memoir deals with the great structural lines of Central America and of the Caribbean Sea, including also the adjacent portion of the South American continent. In this the author to a certain extent reflects the views of Suess. It is a question of high tectonics, which has only an indirect bearing on the comparative merits of the Panama and Nicaragua routes. The author supplies his readers with a very useful sketch-map, a perusal of which will enable them to follow his views. The main conclusion with which we are concerned is the establishment of a hypothetical line which he calls an *arête de rebroussement*. This, he says, is the true line of division between North America, including the Caribbean Sea, and South America; its results, as regards volcanoes and earthquakes, have the effect of producing a region of calms, a sort of *dead angle*, where Panama has the good fortune to be situated at about an equal distance from two dangerous lines.

The following are his conclusions:—

There are no volcanoes around Panama, all eruption having ceased since the Miocene: this is the first point and the most important of all.

With the exception of the earthquake of 1621, which is even contested, there have never been in the region anything but slight shocks, of which a portion are due to the 'echo' of earthquakes at a distance.

The depression utilized by the scheme of the Panama Canal is not a transverse fracture.

The depression of the Pacific coast, and especially the sinking in of the Bay of Panama, in favour of which view there are numerous indications, should not be regarded as phenomena in the course of operation, but as phenomena actually effected, at any rate as regards the actual geological period. In this there is no special cause for mobility of the soil.

Lastly, the position of the lines of folding, and the distribution, according to these lines, of volcanic or seismic activity, show that Panama is situated in a kind of dead angle, in a tranquil zone, at an equal distance to the north and south of the last lines of disturbance.

Thus, all these considerations, whether we regard them from a statistical, a volcanic, or a tectonic point of view, lead to the same result; they allow us to conclude that Panama is the most stable and the least threatened region of Central America. W. H. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 18th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Great Saint-Lawrence-Champlain-Appalachian Fault of America, and some of the Geological Problems connected with it." By Henry M. Ami, M.A., D.Sc., F.G.S.

The extent, earth-movements, and striking characteristics of this fault-line and of the geological formations which occur along this line of weakness in the earth's crust, with special reference to the formations in British North America, were discussed.

Recent investigations in the succession of faunas and geological formations in Eastern Canada have emphasized the fact that those formations which occur to the south and south-east of this great dislocation are strikingly like the geological formations referable to the same geological systems in Great Britain and Western Europe. The fault, as it is traced to-day, appears to divide the geological formations of the Maritime Provinces and Canada into two distinct geological provinces—one, east of the fault, in which the several formations resemble both lithologically and palæontologically the British succession; the other, to the west of this great fault, where there occurs the typical American or epicontinental type of succession.

2. "The Point-de-Galle Group (Ceylon): Wollastonite-Scapolite-Gneisses." By Ananda K. Coomáraswámy, Esq., B.Sc., F.L.S., F.G.S.

The chief rock-types vary from basic pyroxene-sphene-scapolite-rock, through intermediate rocks composed of pyroxene, scapolite, and wollastonite, with felspar and quartz subordinate or abundant, to acid types made up of orthoclase-microperthite or coarse-grained quartzo-felspathic rocks. They differ from the normal types belonging to the Charnockite Series in their somewhat coarser grain, in the presence of wollastonite, scapolite, and sphene, the existence of definite dykes and segregation-veins crossing the foliation, and in the absence of garnet, hypersthene, original mica, and hornblende; but they resemble the series in the variability of chemical and mineralogical composition, in the conspicuous foliation, the common strike, the petrological character of the acid types, and in the local tendency to graphic structures. The foliation, dykes, weathering, and relationship to the Charnockite Series are described: and an account is given of the more important of the minerals. The rocks must be classed as orthogneisses, and the wollastonite and scapolite are original minerals. Possibly the richness in lime is due to the absorption of a mass of limestone by a portion of the Charnockite Series. If this be the case, the lime-silicates must be regarded as endomorphic contact-minerals. On the other hand, the local richness in lime might be due to an original variation in the constitution of the magma. The rocks show a progressive differentiation from basic to acid types, the coarse segregation-veins being the last product of the process. That the rocks have not suffered from earth-movement since their complete consolidation is evidenced by their microscopic characters, while the interlocking of the minerals at the junction of the segregation-veins with the matrix shows that the veins are of contemporaneous character.

3. "On the Jurassic Strata cut through by the South Wales Direct Line between Filton and Wootton Bassett." By Professor Sidney Hugh Reynolds, M.A., F.G.S., and Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

In this section a thin bed of typical Cotham Marble is followed by the 'White Lias,' and that by the Lower Lias, which in this district attains a thickness of about 200 feet. The following zones are represented: (1) the *Planorbis*-beds, containing the *Ostrea*-beds and the *Cidaris*-shales; (2) the *Angulatus*-beds, including the *Conybeari* sub-zone; (3) probably the *Bucklandi*-bed; (4) the *Turneri*-shales; (5) the *Oxynotus*-beds; (6) the *Armatus* and *Jamesoni*-beds; and (7) the *Capricornus*-zone. The strata are remarkably shaly, limestone being predominant only at the base. The typical ironshot Marlstone is only a few feet thick, and the Upper Lias is reduced to a thickness of about 10 feet. The latter consists of a compact, cream-coloured marl with *Ammonites falcifer*, a compact marly limestone with *Amm. communis*, and a pyritic bed containing *Amm. bifrons*. The Cotteswold Sands are 185 feet thick, and contain, at several horizons, hard marly beds with *Amm. striatulus*. They are capped by the Cephalopod Bed, in which Mr. S. S. Buckman has recognized four Ammonite-zones.

The Inferior Oolite has at its base a rock on the horizon of the 'Pea-Grit' followed by Oolitic limestones and '*Trigonia*-Grit.' It is

succeeded by an Oolitic limestone of considerable thickness containing fossils of the Fullers' Earth type, and forming a passage between the Inferior Oolite and the Fullers' Earth, which comes next in succession. Above this are sandy limestones, passage-beds, with *Amm. gracilis*, a form found in the Stonesfield 'Slate.' The Great Oolite consists of white Oolitic limestones with a *Pholadomya*-bed below, and an upper series of wedge-bedded Oolitic limestones containing lenticular patches of clay and sand with a Bradford Clay fauna. The Forest Marble, which is of great thickness and monotonous character, consists chiefly of shales, with bands of sandy, shelly, and Oolitic limestones. It is followed by the Cornbrash. The Oxford Clay with the usual zones, and the Corallian clays and pisolite close the sections. Fossil lists and palæontological notes on each subdivision are given.

The next meeting of the Society will be held on Wednesday, November 5th, 1902.

CORRESPONDENCE.

NOTE ON A NEARLY COMPLETE SPECIMEN OF *ICHTHYOSAURUS THYREOSPONDYLUS* FROM THE KIMERIDGE CLAY OF SPEETON.

Sir,—It will be well to put on record a recent find of this uncommon species, especially as the remains now discovered are more complete than any previously recorded, and largely increase our knowledge of the osteology of this animal. While examining some recent exposures to the north of the Speeton "Middle Cliff," Mr. C. G. Danford, of Reighton, detected some vertebrate remains. He was successful in the course of several days in excavating 53 vertebræ, a large number of ribs, the lower jaw, and portions of paddles, all clearly belonging to one individual. Dr. Smith Woodward has identified the remains as those of *Ichthyosaurus thyreospondylus*, Owen, and associated fossils confirm the age to be Kimeridgian. The vertebræ of this species were figured by Phillips in his "Geology of Oxford," 1871, and, so far as I can find, no other portions of the skeleton were known until the discovery of the present specimen. Yorkshire is also a new locality for the species.

Mr. Danford has generously placed the specimen in the Hull Municipal Museum. This Museum, which is now Corporation property, has as a nucleus the collections of the old Literary and Philosophical Society, and as at present an attempt is being made to get together a typical local collection of fossils, the gift of this skeleton is a most opportune one.

The only other important remains of sauria from the Kimeridge Clay of Yorkshire were found in a brick-pit near South Cave many years ago, and consist of two large paddle-bones, some vertebræ, etc. These also the Hull Museum has been fortunate enough to secure, through the generosity of Mr. G. W. B. Macturk.

Thos. Sheppard, F.G.S.

Hull Museum.

THE RIVERS OF WALES.

SIR,—May I be permitted to assure Mr. Strahan that it is not his criticisms to which I object, even though he still finds the second part of my paper too great a tax upon his credulity. What really concerns me, as a worker in the Principality, is, that the Quarterly Journal of the Geological Society should be open to speculation about the rivers of South Wales and closed to speculation about those of North Wales. PHILIP LAKE.

August 8, 1902.

LITTORAL DRIFT.

SIR,—My friend Mr. W. H. Wheeler's new book on the Sea-Coast has been reviewed with such universal commendation that it may seem invidious to offer any word of criticism. But, as my own work in the same direction was reviewed in the GEOLOGICAL MAGAZINE some years ago, and as if Mr. Wheeler is right I am most undoubtedly wrong, it may be as well to point out briefly my reasons for divergence, leaving it to experts to decide the questions at issue.

Mr. Wheeler's conclusions are based, explicitly or implicitly, on some six hypotheses, viz.:—

(1) That the tidal wave is a wave of translation.

(2) That the flood-tide current generally, as a current, is a stronger current than the ebb-tide current.

(3) That the flood-tide current generates tidal wavelets of translation.

(4) That sea waves on approaching the shore become waves of translation.

(5) That sea waves approaching the shore raise the mean level of the water, with the effect of adding temporarily to the volume of water above mean level, as compared with the volume below that level.

(6) That the proportion of height to length of wave may be as much as 1 to 3.

Mr. Wheeler incidentally discusses a wave with the assumed proportions of 30 feet long and 10 feet high.

It would be scarcely possible to discuss the evidence, mathematical, observational, and experimental, on these six points, under some two or three hundred pages.

In this as in many other cases controversialists do not use the same terms with the same meanings, so that the nomenclature must first be cleared, e.g.:—

(1) The tidal wave, due to the attraction of moon and sun, gives rise to two currents, an ebb and a flood; but, when the flood runs up a channel such as the Severn, and creates a 'bore,' observers are apt to speak of such bore as the tidal wave itself, instead of as a subsidiary wave due to the retardation of the tidal flow-current in the river.

(2) As the flood-tide current at sea runs, as a rule, three or more hours after high-water, the term 'flood tide' is ambiguous.

Sir George Airy observes that, "in the tide wave and every other wave which travels along a channel . . . . this law is universal, that the water is travelling forward with its greatest speed at the time of high water, or at the top of the wave" ("Tides and Waves," art. 183). The flood-tide current usually flows from 'half flood' to 'half ebb'; and the ebb current ebbs from half ebb to half flood. Thus, when Mr. Wheeler discusses the effect of the flood-tide current it is most important to know exactly what is meant; for the water does not turn in direction until the tide has been rising some three hours, unless affected by special circumstances.

(3) Then there is another important source of confusion of ideas among writers generally. The great tidal wave is often spoken of as though a wave which, crossing the Atlantic, impinges on the coasts of Europe; whereas of course the motion of the great tidal wave is away from the British shores, travelling from east to west. Thus no little confusion arises between the ideas of the great tidal wave and the tidal currents which run in an out of our British waterways. The generation of tidal wavelets of translation by the flood-tide current, or any tidal current, is not in accordance with my own experience at the seaside during the past fifty years.

(4 and 5) These hypotheses are not confirmed either by my own observations or experiments.

(6) A proportion of wave length to height of only 3 to 1 is to myself inconceivable. My boat was 26 feet long with a freeboard of about 2 feet. I should not be writing this letter if one were liable to encounter such waves or anything approaching them in the English Channel. I should say that a length to height of 20 to 1 would be very excessive; and that 40 to 1 would be much nearer the mark. My friend Mr. Howard Fox, F.G.S., has himself observed waves with a period of twenty seconds at the Lizard Signal Station. These waves would be just over 2,000 feet long. Sir G. G. Stokes records waves with a period of 17 seconds.

It is true that Littoral Drift has a limited interest for geologists; but the action of waves on the coast, and on sea-bottoms to at least a depth of 100 fathoms, affords geological and palæontological problems of very great interest indeed, so that it is advisable to see that the foundations are securely laid.

If any mathematician who can speak with authority would write a little primer on wave-action, similar to Sir Archibald Geikie's shilling Primer of Geology, it would be invaluable. For my own instruction, when working and experimenting, I was entirely dependent on the kindness of Lord Rayleigh, who was ever ready to explain what I failed to understand; and of Sir G. G. Stokes, who worked out a special case for me, since published in the Transactions of the Devonshire Association.[1] But, so far as my experience goes, the information generally accessible to non-mathematicians is, on this subject, worse than useless, being almost invariably misleading.

[1] Trans. Devonshire Assoc., 1887, p. 512.

Of course, I accept implicitly all Mr. Wheeler's own observations; but, as I demur to the aforesaid six hypotheses, I am unable to accept his explanations. A. R. Hunt.

Southwood, Torquay.
July 17, 1902.

LAKES OF SNOWDONIA.

Sir,—In the Geological Magazine for 1900 (Dec. IV, Vol. VII, p. 58) Mr. Dakyns criticizes a paper published in a previous volume of the Magazine, in which Mr. Adie and I treat of the Lakes of Snowdonia. Mr. Dakyns has convicted me of two mistakes, one in a matter of observation, the other in the manner of expression of a statement. For each of these mistakes I am alone responsible.

I had hoped to accept Mr. Dakyns' polite invitation to go over the ground with him, but various circumstances have prevented me from doing so, and I have therefore awaited the publication of Mr. Jehu's paper upon the Lakes of Snowdonia (Trans. Roy. Soc. Edinb., vol. ix, p. 419) before making my confession of error.

Mr. Jehu informs me that I undoubtedly mistook an artificial diversion of the stream issuing from Glaslyn for a natural one. As he has not corrected this serious error in a prominent manner in his paper, I feel bound to do so. I can only plead in mitigation of my offence that the outlet was examined towards dusk on a sunny day in the Easter vacation; nevertheless, as our paper was partly occupied with criticism of the views of others, I feel that I ought to have revisited the lake before making my statement.

The other matter refers to the bed of the Colwyn, which I said "runs over drift." I should have said that drift extends along the lower part of the valley beneath or near the bed of the river.

Concerning other parts of Mr. Dakyns' paper I may have something to say in the future, but I feel that no further time should be allowed to elapse before acknowledging mistakes to which attention has been drawn in so straightforward a manner. John E. Marr.

Cambridge, *August*, 1902.

OBITUARY.

PHILIP JAMES RUFFORD, F.G.S.,

Of the Hastings and St. Leonards Museum Association.

Born January 26, 1852. Died June 19, 1902.

It is with deep regret we record the death of Mr. Philip Rufford, F.G.S., of 37, Magdalen Road, St. Leonards-on-Sea, a most ardent geologist and enthusiastic naturalist, who had for some years devoted himself very earnestly to the advancement of the Hastings and St. Leonards Museum forming a part of the Brassey Institute, Hastings, in which he spent a considerable portion of his time.

Philip James Rufford, the only son of the late Rev. Philip Rufford, M.A., Rector of Thorne-Coffin, Somerset, was born at Great Alne,

Ruffordia Goepperti (Seward), a new fossil fern from the Wealden Formation, Ecclesbourne, Hastings, discovered by Mr. Philip J. Rufford, F.G.S.

[See Mr. A. C. Seward's Catalogue of Wealden Plants in the British Museum (Nat. Hist.), Part I, pp. 75–86, pl. iv, 1894.]

Warwickshire, January 26th, 1852. He was brought up as a Civil Engineer, but early in his career his health broke down and he was compelled to abandon his profession, and about the year 1888 he settled with his mother in The Croft at Hastings. Having by careful study and observation previously acquired a very considerable knowledge of geology, on coming to reside in Hastings he devoted all his time and attention to collecting fossils from the Wealden strata of the neighbourhood, especially at Ecclesbourne and Fairlight. Mr. Rufford's favourite collecting-ground was along the sea-shore from Rock-a-Nore to Cliffs End. He was fortunate in obtaining a very fine collection of Wealden plants, which he disposed of at a nominal valuation to the British Museum (Natural History), Cromwell Road, only stipulating that they should, as soon as possible, be figured and described by the Museum. This task was ably undertaken by Mr. A. C. Seward, M.A., F.R.S., in 1893–4 and 5. In the preface to vol. i the Keeper of Geology writes: "We are fortunate in possessing many of Mantell's original specimens of Wealden plants, but, although historically of great interest, they are largely superseded by those recently obtained by Mr. P. Rufford, whose fine collection has lately been acquired for the National Museum" (p. vi op. cit.). In the same volume Mr. Seward describes 147 specimens, mostly PTERIDOPHYTA, from Mr. Rufford's collection. Amongst these is a new genus of ferns dedicated to the discoverer, by Mr. A. C. Seward, as *Ruffordia*, gen. nov. (p. 75, pl. iv), having a finely divided form of frond, not unlike *Asplenium fragrans*, Sby., in habit. In vol. ii Mr. Seward illustrates the *Cycadites* and *Zamites* (with their fruits and stems), and the Coniferæ, and refers to no fewer than 196 specimens from Mr. Rufford's collection, many of which he describes and figures. This interesting series of Wealden plants is now all well arranged and exhibited in Gallery No. X, Department of Geology, British Museum (Natural History). The ferns and zamia-leaves from Ecclesbourne are very beautiful, and form a most attractive part of the collection.

The Museum of the Brassey Institute commenced to assume an organized and definite shape in 1891, when the Committee purchased a part of the Beckles Collection of Wealden and other fossils. Mr. Rufford, who was then a member of its Committee, took upon himself the arduous task of selecting, naming, and arranging these objects with his own hands, adding largely to the geological section of the Museum from his own private cabinet. He also contributed a series of Recent marine, land, and fresh-water Mollusca, Recent Sponges, Hydroids, Echinoderms, Polyzoa, etc. Owing to ill-health he last year visited Italy and stayed the winter in Rome. Early in the spring he spent some weeks in Naples, where he was much gratified by the kindness he received from Dr. Anton Dohrn, Director of the Marine Zoological Station, and from his assistants, in his efforts to gain some knowledge of the living sea fauna for furthering his studies at Hastings. His loss to the Museum will long be felt by all his colleagues who served with him on the Committee.